This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

+ *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.

+ *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.

+ *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.

+ *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at `http://books.google.com/`

METALLOGRAPHY

AS A SEPARATE SCIENCE,

OR

THE STUDENT'S HANDBOOK OF METALS.

DESIGNED AS AN ELEMENTARY WORK

FOR THE USE OF SCHOOLS AND SCIENCE CLASSES,

AND CONSISTING OF

NOTES ON FIFTY-FIVE METALS,

THEIR VARIOUS PROPERTIES, THEIR HISTORY,

THE LOCALITIES IN WHICH THEY ARE FOUND,

AND THE PRINCIPAL USES TO WHICH THEY ARE APPLIED.

BY

THOMAS ALLEN BLYTH,

M.A., Ph.D., F.E.I.S., F.G.S.E.,

UNIVERSITY OF GÖTTINGEN.

LONDON:
LONGMANS, GREEN, READER, AND DYER.

1871.

188. f. 37.

BEDFORD:

PRINTED BY JAMES B. PORTER, 7, HIGH STREET.

DEDICATION.

TO THE PRESIDENT, COUNCIL, AND FELLOWS

OF THE

EDINBURGH GEOLOGICAL SOCIETY.

Bedford,

January 1, 1871.

My Lords and Gentlemen,

Permit me, most respectfully, to inscribe to you the following pages, as a trifling acknowledgment of the honour you did me on December 22, 1864, by unanimously electing me a Fellow of your Society, and, more especially, of the further honour you conferred upon me on March 22, 1866, by admitting me "to all the privileges of Life Membership," which honor, I suppose, in the words of Cæsar, *ante id tempus accidit nulli.*

I have the honor to remain,

My Lords and Gentlemen,

Your obedient Servant,

T. A. BLYTH.

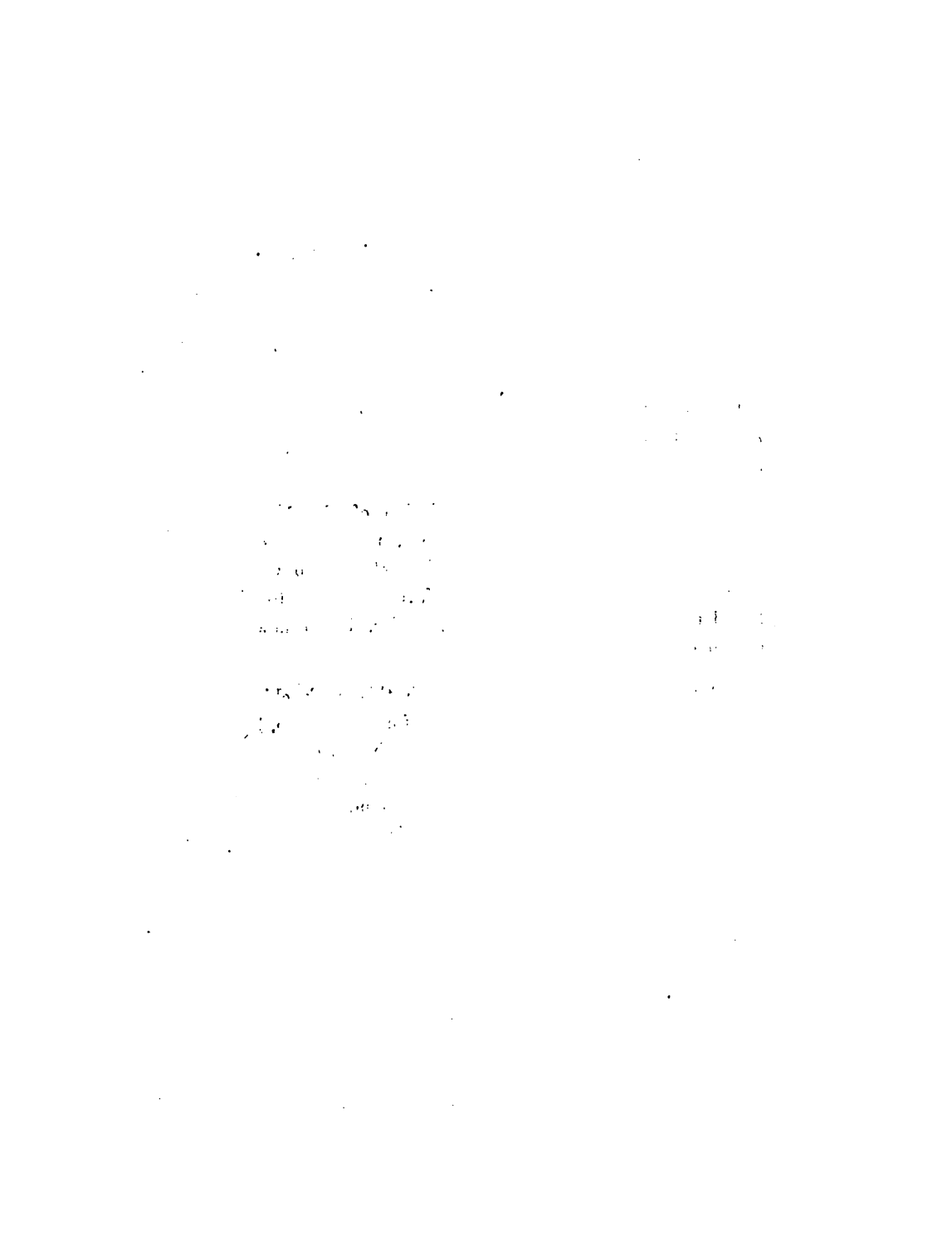
PREFACE.

This treatise, consisting of a reprint of the author's contributions to various magazines, is issued merely as an elementary work on the science.

Metallography is simply a description of the Metals, their various properties, their history, the localities in which they are found, and the principal uses to which they are applied. The term itself, though not to be found in the smaller English dictionaries, is no newly-coined expression.

The notes on each metal, of which this work chiefly consists, were not originally intended for publication, but for the writer's own private use. Although they have been carefully revised by the author, he nevertheless believes that there are still inaccuracies to be found. Notwithstanding, however, its imperfections, it is hoped that this handbook will be found useful, easy, and well-adapted for that class of persons for whom it is now published.

18, *Peel Street, Bedford,*
January 1, 1871.



INTRODUCTION.

"Yes, yes, all have a voice! the Heavens above,
The Earth beneath, and things that under earth
Lie deeply hidden—all send out a sound,
And lecture man, the wandering and the lost,
In holy lore."

NOTHING, perhaps, tends more to enlarge our ideas of the wisdom and power of the Divine Being, and, consequently, to exalt the mind, than to contemplate some particular work of nature, and consider how admirably it is adapted to answer the purpose for which it was intended. If we accustom ourselves to this, our opinion must coincide with that of the Psalmist—we must be convinced that none but "a fool" can say, "There is no God!" For

"That there is a God,
All nature cries aloud through all her works;"

and being convinced of this, how naturally should we, with another bard, exclaim—

"And if a God there is, that God how great!"

What "work of nature," then, deserves more of our attention than the Metals—that class of elementary bodies which, either separately or in combination, appeal daily and even hourly, to our senses in the implements and utensils of civilized life, and exercise a very important influence upon the comfort of all mankind? Had it not been for their existence, our dwelling-houses would have been supplied with only a very small proportion of the various articles of comfort, elegance, and even luxury, which they now contain. There are, indeed, very few things in our homes which are not indebted to one, at least, of the metals for their shape

and appearance; while there are hundreds, yes, and we might have said thousands, of articles which we daily see and employ for one purpose or another, made either entirely or partly of metals.

The Science of the Metals, however, has not reached that high position among the studies of young persons, and, indeed, among those of the more educated masses of the people, to which it is no doubt destined before long to attain—a station which, in all probability, will not be second to Natural History, or Astronomy. Nevertheless, in describing the various metallic substances which the Great Creator of the Universe has placed in the bowels of the earth for man, each of which, no doubt, were intended by Him for some special purpose; or, rather, we should have said, in calling attention to the various metals which man from time to time has eliminated, and added to his great collection, or "Museum of Metals," if we may use the phrase,—it is not our intention to imitate the majority of our contemporary authors of scientific works, and speak in what is termed a "popular style" (that is, not to employ any technicality or expression which belongs almost exclusively to the science, but to bring down the science to the acquirements of the individual), for we prefer to copy the minority, who endeavour to conduct the pupil step by step into the subject; because, as it is, indisputably, highly essential that the chemist should know and understand all the peculiar terms employed in chemistry, it is no less important for the student in Mineralogy and Metallography to understand the various expressions made use of in those sciences. We shall, therefore, not refrain from employing such phrases or terms, taking care at the same time, to explain and illustrate them as we proceed.

METALLOGRAPHY;

OR

THE SCIENCE OF THE METALS.

CHAPTER I.

DERIVATION AND MEANING OF "METALLOGRAPHY."—THE NAMES OF THE METALS.—DERIVATION OF NAMES.—SYMBOLS.—EQUIVALENTS.—SPECIFIC GRAVITIES.—DATES OF DISCOVERIES.—NAMES OF ELIMINATORS.—EXPLANATION OF THE TERMS, METALLIC LUSTRE, SPECIFIC GRAVITY, FUSIBILITY, AND CRYSTALLIZATION.

THE word METALLOGRAPHY is derived from two Greek words, *metallon*, a metal, and *graphé*, a writing or description, and has been applied to that science which describes and treats of the properties of that very large class of simple or elementary substances called Metals. Of these substances there are no fewer than fifty-five.

Several of them are very rare, and at present of no practical use; nevertheless, the advance of knowledge will probably elicit valuable properties.

Their names, arranged alphabetically, are as follows:—

	Name of Metal.	Derivation of Name.	Symbol.	Equivalent.	Specific Gravity.	Date of Discovery.	Name of Eliminator.
1	Aluminium	Lt. *alumen*, alum	Al.	13·7	2 600	1828	Wöhler.
2	Antimony	Gk. *anti*, against; Fr. *moine*, a monk	Sb. 1	129·0	6·702	1490	Basil Valentine.
3	Arsenic	Gk. *arsenicon*, potent	As.	75·0	5·884	1733	Brandt.
4	Barium	Gk. *barys*, heavy	Ba.	68·5		1807	Sir H. Davy.
5	Bismuth	Ger. *Weiss Muth*, white matter	Bi.	213·0	9·830	1530	Agricola.
6	Cadmium	Gk. *cadmeia*, calamine	Cd.	56·0	8·604	1818	Stronmeyer.
7	Cæsium	Lat. *cæsius*, sky blue	Cs.	117·6		1860	Kirchoff and Bunsen
8	Calcium	Lat. *calx*, lime	Ca.	20·0		1807	Davy.
9	Cerium	The planet *Ceres*	Ce.	47·0		1804	Hisinger and Berzelius.
10	Chromium	Gk. *chroma*, colour	Cr.	26·7	5·900	1797	Vauquelin.
11	Cobalt	Ger. *Kobold*, an evil spirit	Co.	29·5	7·834	1733	Brandt.
12	Columbium*	*Columbus*, the discoverer of America	Ta. 2	184·0	5·610	1802	Hatchett.
13	Copper	The island of *Cyprus*	Cu. 3	31·7	8·958		The Ancients.
14	Didymium	Gk. *didumos*, twins	Di.	49·6		1840	Mosander.
15	Erbium		E.			1840	Mosander
16	Glucinium	Gk. *glukos*, sweet	Gl.	6·9	2·100	1828	Wöhler.
17	Gold	Sax. *gold*, yellow	Au. 4	197·0	19·361		The Ancients.
18	Ilmenium	The lake *Ilmen*, in Russia	Il.				Hermann.
19	Indium					1863	Reich and Ritter.
20	Iridium	Lat. *Iris*, the rainbow	Ir.	99·0	18·680	1803	Tennant.
21	Iron	Sax. *iren*, *irenn*, iron	Fe. 6	28·0	7·770		The Ancients.
22	Lanthanium	Gk. *lanthano*, to conceal	La.	47·0		1839	Mosander.
23	Lead	Gk. *molybdos*, galena (the ore of lead)	Pl. 6	103·7	11·445		The Ancients.
24	Lithium	Gk *lithos*, a stone	Li.	6·5	0·590	1818	Arfwedson.
25	Magnesium	*Magnesia*, in Asia Minor	Mg.	12·2	1·750	1829	Bussy.
26	Manganese	*Mangana*, in East Indies	Mn.	27·6	8·013	1774	Bergman and Scheele.
27	Mercury	The planet *Mercury*	Hg. 7	100·0	13·568		The Ancients.
28	Molybdenum	Gk. *molybdos* (because mistaken for lead)	Mo.	46·0	8·611	1782	Hielm.

29	Nickel	Ger. *Kupfernickel*, base copper	Ni.	29·6	8·278	1751	Cronstedt.
30	Niobium	*Niobe*, daughter of Tantalus	Nb.			1845	H. Rose.
31	Norium	*Nore*, ancient name of Norway	No.				Svanberg.
32	Osmium	Gk. *osme*, odour	Os.	99·6		1803	Tennant.
33	Palladium	The planet *Pallas*	Pd.	53·3	11·860	1803	Wollaston.
34	Pelopium	*Pelops*, son of Tantalus	Pe.			1845	H. Rose.
35	Platinum	Spanish, *Platina*, little silver	Pt.	98·7	21·530	1741	Wood.
36	Potassium	*Pot-ashes*	K. 8	39·2	0·865	1807	Davy.
37	Rhodium	Gk. *rhodon*, a rose	R.	52·2	10·649	1803	Wollaston.
38	Rubidium						Bunsen.
39	Ruthenium		Ru.	52·2	11·400	1844	Klaus.
40	Siderium					1863	E. Sonstadt.
41	Silver	Sax. *seolfer*, *seolfor*, *sylfor*	Ag. 9	108·1	10·474		The Ancients.
42	Sodium	Soda	Na. 10	23·0	0·972	1807	Davy.
43	Strontium	*Strontia*, in Scotland	Sr.	43·8	2·540	1807	Davy.
44	Tellurium	Lat. *tellus*, the earth	Te.	64·2	6·115	1782	Müller and Klaproth.
45	Terbium		Tb.			1840	Mosander.
46	Thallium						Crooke.
47	Thorinum	The fabulous ancient deity, *Thor*	Th.	59·6		1827	Berzelius.
48	Tin	Sax. *Tin*	Sn. 11	59·0	7·283		The Ancients.
49	Titanium	*Titanes*, sons of Cœlus and Terra	Ti.	25·0	5·300	1791	Gregor and Klaproth.
50	Tungsten	Swedish, *tungsten*, heavy stone	W. 12	95·0	17·600	1781	D'Elhuyart.
51	Uranium	The planet *Uranus*	U.	60·0	9 000	1789	Klaproth.
52	Vanadium	*Vanadis*, the goddess *Freia*	V.	68·6		1801	Del Rio and Sefström
53	Yttrium	*Ytterby*, in Sweden	Y.	32·2		1828	Wöhler.
54	Zinc	Ger. *Zinken*, nails	Zn.	32·6	7 191	1530	Paracelsus Theophrastus
55	Zirconium	Ceylonese, *zircon*, four-cornered	Zr.	22·4		1824	Berzelius.

1. Sb.—Stibium. 2. Ta.—Tantalium. 3. Cu.—Cuprum. 4. Au.—Aurum. 5. Fe.—Ferrum. 6. Pl.—Plumbum. 7. Hg.—Hydrargyrum. 8. K.—Kalium. 9. Ag.—Argentum. 10. Na.—Natrium. 11. Sn.—Stannam. 12. W.—Wolframium.

* Called also Tantalum and Tantalium from *Tantalite*, name of a mineral.

	Name of Metal.	Derivation of Name.	Symbol.	Equivalent.	Specific Gravity.	Date of Discovery.	Name of Eliminator.
1	Aluminium	Lt. *alumen*, alum	Al.	13·7	2 600	1828	Wöhler.
2	Antimony	Gk. *anti*, against; Fr. *moine*, a monk	Sb. 1	129·0	6·702	1490	Basil Valentine.
3	Arsenic	Gk. *arsenicon*, potent	As.	75·0	5·884	1733	Brandt.
4	Barium	Gk. *barys*, heavy	Ba.	68·5		1807	Sir H. Davy.
5	Bismuth	Ger. *Weiss Muth*, white matter	Bi.	213·0	9·830	1530	Agricola.
6	Cadmium	Gk. *cadmeia*, calamine	Cd.	56·0	8·604	1818	Stronmeyer.
7	Cæsium	Lat. *cæsius*, sky blue	Cs.	117·6		1860	Kirchoff and Bunsen
8	Calcium	Lat. *calx*, lime	Ca.	20·0		1807	Davy.
9	Cerium	The planet *Ceres*	Ce.	47·0		1804	Hisinger and Berzelius.
10	Chromium	Gk. *chroma*, colour	Cr.	26·7	5·900	1797	Vauquelin.
11	Cobalt	Ger. *Kobold*, an evil spirit	Co.	29·5	7·834	1733	Brandt.
12	Columbium*	*Columbus*, the discoverer of America	Ta. 2	184·0	5·610	1802	Hatchett.
13	Copper	The island of *Cyprus*	Cu. 3	31·7	8·958		The Ancients.
14	Didymium	Gk. *didumos*, twins	Di.	49·6		1840	Mosander.
15	Erbium		E.			1840	Mosander
16	Glucinium	Gk. *glukos*, sweet	Gl.	6·9	2·100	1828	Wöhler.
17	Gold	Sax. *gold*, yellow	Au. 4	197·0	19·361		The Ancients.
18	Ilmenium	The lake *Ilmen*, in Russia	Il.				Hermann.
19	Indium					1863	Reich and Ritter.
20	Iridium	Lat. *Iris*, the rainbow	Ir.	99·0	18·680	1803	Tennant.
21	Iron	Sax. *iren*, *irenn*, iron	Fe. 5	28·0	7·770		The Ancients.
22	Lanthanium	Gk. *lanthano*, to conceal	La.	47·0		1839	Mosander.
23	Lead	Gk. *molybdos*, galena (the ore of lead)	Pl. 6	103·7	11·445		The Ancients.
24	Lithium	Gk *lithos*, a stone	Li.	6·5	0·590	1818	Arfwedson.
25	Magnesium	*Magnesia*, in Asia Minor	Mg.	12·2	1·750	1829	Bussy.
26	Manganese	*Mangana*, in East Indies	Mn.	27·6	8·013	1774	Bergman and Scheele.
27	Mercury	The planet *Mercury*	Hg. 7	100·0	13·568		The Ancients.
28	Molybdenum	Gk. *molybdos* (because mistaken for lead)	Mo.	46·0	8·611	1782	Hielm.

29	Nickel	Ger. *Kupfernickel*, base copper	Ni.	29·6	8·278	1751	Cronstedt.
30	Niobium	*Niobe*, daughter of Tantalus	Nb.			1845	H. Rose.
31	Norium	*Nore*, ancient name of Norway	No.				Svanberg.
32	Osmium	Gk. *osme*, odour	Os.	99·6		1803	Tennant.
33	Palladium	The planet *Pallas*	Pd.	53·3	11·860	1803	Wollaston.
34	Pelopium	*Pelops*, son of Tantalus	Pe.			1845	H. Rose.
35	Platinum	Spanish, *Platina*, little silver	Pt.	98·7	21·530	1741	Wood.
36	Potassium	*Pot-ashes*	K. 8	39·2	0·865	1807	Davy.
37	Rhodium	Gk. *rhodon*, a rose	R.	52·2	10·649	1803	Wollaston.
38	Rubidium						Bunsen.
39	Ruthenium		Ru.	52·2	11·400	1844	Klaus.
40	Siderium					1863	E. Sonstadt.
41	Silver	Sax. *seolfer*, *seolfor*, *sylfor*	Ag. 9	108·1	10·474		The Ancients.
42	Sodium	Soda	Na. 10	23·0	0·972	1807	Davy.
43	Strontium	*Strontia*, in Scotland	Sr.	43·8	2·540	1807	Davy.
44	Tellurium	Lat. *tellus*, the earth	Te.	64·2	6·115	1782	Müller and Klaproth.
45	Terbium		Tb.			1840	Mosander.
46	Thallium						Crooke.
47	Thorinum	The fabulous ancient deity, *Thor*	Th.	59·6		1827	Berzelius.
48	Tin	Sax. *Tin*	Sn. 11	59·0	7·283		The Ancients.
49	Titanium	*Titanes*, sons of Cœlus and Terra	Ti.	25·0	5·300	1791	Gregor and Klaproth.
50	Tungsten	Swedish, *tungsten*, heavy stone	W. 12	95·0	17·600	1781	D'Elhuyart.
51	Uranium	The planet *Uranus*	U.	60·0	9 000	1789	Klaproth.
52	Vanadium	*Vanadis*, the goddess *Freia*	V.	68·6		1801	Del Rio and Sefström
53	Yttrium	*Ytterby*, in Sweden	Y.	32·2		1828	Wöhler.
54	Zinc	Ger. *Zinken*, nails	Zn.	32·6	7 191	1530	Paracelsus Theophrastus
55	Zirconium	Ceylonese, *zircon*, four-cornered	Zr.	22·4		1824	Berzelius.

1. Sb.—Stibium. 2. Ta.—Tantalium. 3. Cu.—Cuprum. 4. Au.—Aurum. 5. Fe. –Ferrum. 6. Pl.—Plumbum. 7. Hg.—Hydrargyrum. 8. K.—Kalium. 9. Ag.—Argentum. 10. Na.—Natrium. 11. Sn.—Stannam. 12. W.—Wolframium.

* Called also Tantalum and Tantalium from *Tantalite*, name of a mineral.

These substances are distinguished as a class from all other bodies by their peculiar brilliancy, which has been termed by metallographers *metallic lustre;* and it arises out of their opacity and reflective power. But there are other properties besides this by which we may distinguish these useful bodies—such as their weight or specific gravity, fusibility, ductility, and malleability. When we speak of the specific gravity of a metal, we mean its weight as compared with that of water, which, as a standard of comparison, is called one. Thus, for instance, the specific gravity of platinum is marked 21·53 in the foregoing table; that is, it is rather more than 21 times as heavy as water. Lithium, on the other hand, which is one of the lightest of the metals, is only ·59 as heavy as water; or, in other words, water is nearly twice as heavy as lithium, which, on this account, will float.

Again, all the metals are *fusible* (*i.e.*, capable of being poured out—from the Latin *fundo*, I pour out), but the degree in which they possess this quality is considerably diversified. Platinum, for example, requiring to be melted by the oxy-hydrogen blow-pipe, whilst mercury or quicksilver, is not only fluid at the ordinary temperature of our atmosphere, but continues so even in a degree far beyond that at which water becomes solid; it actually requires a cold of 72 degrees below the freezing point of Fahrenheit's thermometer—an intensity of cold not known in our climate—in order to solidify. If, when in a state of fusion, the metals be allowed to cool slowly and quietly, they all crystallize, most of them assuming the form of the octohedron. The word *crystallization* is derived from the Greek *krustallos*, ice or crystal, and has been applied to the operation in nature as well as art, in which various earths, salts, and metallic substances, passing from a fluid to a solid state, assume certain geometrical forms. Pure carbon is capable of crystallization, though not by art, in which state it is called diamond.

Amidst the great variety of departments which this science embraces, the changes which the metals undergo by their absorption of oxygen from the atmosphere are perhaps more eminently calculated than any other to give a relish for chemical experiments, and to engage the minds of the young in the unremitted examination of the works of the Great Creator of the Universe.

"The philosophic youth
To Nature's voice attends from month to month,
And day to day, through the revolving year;
Admiring, sees her in her every shape,
Feels all her sweet emotions at his heart;
While Truth, divinely breaking on his mind,
Elates his being, and unfolds his powers."

The youth who possesses an intelligent and well-educated mind, is nearly always delighted in discovering the origin, studying the properties, or tracing the past history of any natural object, as revealed in its structure and growth; and the study of the various sections of the animal, vegetable, and mineral kingdoms cannot fail to occupy and charm such an one. The more we, as human beings, inquire and search into the economy of Nature, as displayed in the numberless different objects by which we are surrounded, so far from finding any imperfection, we shall obtain more and more convincing proofs that not only every animal and vegetable, but also every mineral and metal is equally well adapted for the purpose for which it was intended by God. And it is a remarkable fact that the more we magnify the works of Nature, with the assistance of the microscope, the more strikingly do their regularity and beauty show themselves. But this is not the case with the works of man. Take, for instance, a drawing, painting, or engraving; although it may have been executed with the most delicate care that the most clever artist can bestow upon it, yet when placed under the microscope, we are indeed astonished at its appearing so harsh, so rough, so uncomely. It was the study of the works of nature which led the Psalmist to exclaim, "O Lord, how manifold are thy works, in wisdom thou hast made them all; the earth is full of thy riches!" Then

"Canst thou renounce the boundless store
Of charms which Nature to her votary yields?
The warbling woodlands, the resounding shore,
The pomp of groves, and garniture of fields;
All that the genial ray of morning yields,
And all that echoes to the song of even',
And all that the mountains' sheltering bosom yields,
And all the dread magnificence of Heaven?
Canst thou renounce, and hope to be forgiven?"

CHAPTER II.

EXPLANATION OF THE TERMS—MALLEABILITY.—DUCTILITY.—TENACITY.—DILATABILITY.—CONTRACTIBILITY.—VOLATILITY.—MAGNETIC.—OXIDES.—SEMI-TRANSLUCENT.—NATIVE METALS.—ORE.—PHOSPHURET.—SULPHURET.—NATIVE ALLOY.—NATIVE AMALGAM.—AND NOTES ON THE CONDUCTING POWERS OF THE LEADING METALS FOR ELECTRICITY AND HEAT.

CONSIDERED in all its connections, we think that the science of Metallography, cannot fail to produce the most profound admiration and the holiest emotions of reverential fear and humble adoration. When we reflect that there is no part of the universe, no part of the vast empire of His government, in which the great I AM is not present—present Himself, in all the perfections of His being—with the mineral or metal, to give it its formation and peculiar properties; with the insect, to defend it from the many dangers to which it is constantly exposed; and with man, to continue each pulsation of his heart, and preserve him from falling a victim to that life-destroying monster, Death, before the term of his probation in this world shall have been completed;—when we remember that to Him everything, whether belonging to the animal, vegetable, or mineral kingdom, is indebted for its life and breath, its continued existence, or its properties—we cannot but be astonished at the displays of His incomprehensible intelligence and wisdom, the grandeur of His mighty operations, the never ceasing and unbounded effects of His goodness and His love to all the objects which He has created, particularly towards man, the noblest of all His works.

"These are thy wondrous works, Parent of good,
Almighty: thine this universal frame,
Thus wondrous fair; thyself how wondrous then,
Unspeakable! who sitt'st above the heavens
To us invisible, or dimly seen
In these thy lowest works.—Yet these declare
Thy goodness beyond thought, and power divine."

MILTON.

Having dwelt upon the specific gravity, fusibility, and crystallization of the metals, we will now proceed to say something about a few more of the remarkable properties possessed by these very important substances. *Malleability* (from the Latin *malleus*, a hammer) is the property in virtue of which metals may be reduced to thin plates or leaves, either by the hammer, or pressure between rollers. It arises from the willingness of their atoms to cohere in every direction. Among the metals which are malleable to a remarkable degree may be mentioned gold, silver, copper, tin, platinum, lead, zinc, and iron. Gold is superior in malleability to all the rest of the metals; a single grain of it may be made by hammering large enough to cover a space of fifty square inches, whilst the thickness of the leaf is only 1-200,000th part of an inch. But some metals—antimony, bismuth, titanium, and manganese, for instance—are so entirely destitute of this property, that they may be broken by the hammer, and even reduced to powder; they are, therefore, termed *brittle* metals. The word *ductility* is derived from the Latin *duco*, "I lead," and is applied to that property by which metals are susceptible of being drawn or led out into wire; this arises from the strong cohesion of their particles. The following, the most ductile of the metals, are arranged in the order of their ductility:—Gold, silver, platinum, iron, copper, zinc, tin, and lead. Iron, the most abundant and the most useful of the metals, may be drawn into wire not thicker than a human hair; and Dr. Wollaston has produced platinum-wire actually finer than the thread of a spider; while he drew a single grain of gold into wire to the enormous extent of 790 feet, the wire being only 1-30,000th part of an inch thick. Some of the ductile metals, when in the form of wire, are capable of sustaining very heavy weights; this is called their strength or *tenacity*, from *teneo*, the Latin for "I hold"; an iron wire, 1-10th of an inch in diameter, will bear a weight of about 550 lb.; copper, 300 lb.; platinum, 270 lb.; silver, 190 lb.; gold, 150 lb.; zinc, 100 lb.; tin, 40 lb.; and lead, about 20 lb.; avoirdupois weight.

As regards the *dilatability* (from the Latin *dis*, apart; and *latus*, wide—the property of widening in all directions) and *contractibility* (from the Latin *con*, together; and *traho*, I draw—the property by which bodies shrink or contract) of the metals. As soon as they become heated, even before

they are fused, they expand in all directions; and, on cooling, they become contracted in their dimensions. These properties are different in each of the metals; and they vary also in the same metal with every degree of the thermometric scale. Several years ago, the walls of the Conservatoire des Arts et Metiers of Paris threatened to fall by the pressure of the roof upon them: but Molard, knowing that bars of metal alternately heated and cooled would alternately expand and contract, employed this as a mechanical agent in preventing their fall. This he did by passing bars across them, with nuts screwed upon them outside the walls. The bars being heated, expanded, and the nuts were then screwed up to the wall, and the bars left to cool, and by their consequent contraction the walls were drawn together. This operation having been frequently repeated, the walls were at length restored to the perpendicular.

The metals are not by themselves very *elastic* [*i.e.* having the property of springing back to their original form, after this has been altered; (from the Greek, *elauno*, I drive)] or *sonorous* (*i.e.*, giving sound when struck, from the Latin, *sonus*, sound), but there are alloys (or compounds of two or more metals), those of copper and tin, for example—which possess them in a very high degree. Some of the metals are *volatilized* [or made to pass into vapour, or in an aeriform condition—from the English, volatile, which is derived from the Latin, *volo*, I fly] at moderate degrees of heat. Amongst these may be mentioned mercury, cadmium, arsenic, tellurium, zinc, potassium, and sodium. Others, on the contrary, may be exposed to the most intense heat of a wind furnace without being the least vapourized. Iron and nickel are the only two known metals which are capable of being rendered perfectly *magnetic* (*i.e.*, belonging to, or having the properties of a magnet; from the Greek, *magnes*, a magnet). The former of these, only, is found possessing this property in nature; it is an oxide of iron, commonly called the *load-stone*. The metals are certainly the best conductors of *electricity* of all known bodies. The following is a list of the conducting powers of the principal metals for electricity, the diameter of the different wires being equal:—copper, 1,000; gold, 935: silver, 740; zinc, 285; platinum, 165; iron, 160; tin, 155; lead, 85; mercury, 35.

The metals are also good conductors of *heat*, but their conducting powers are very different from each other.

Assuming the conducting power of gold as 100·00, platinum would be 98·10; silver, 97·30; copper, 89·32; iron, 37·43; zinc, 36·38; tin, 30·39; lead, 17·96.

Another peculiar property possessed by the metals is that nearly all of them, when exposed to the action of the air, lose their metallic lustre, by combining more or less with oxygen, which they absorb from the atmosphere; and, in course of time, are converted into earthy-like powders, possessing various colours and properties, which are denominated oxides; such, for example, is the *rust of iron* (or speaking metallographically, *oxide of iron*). Some of the metals take fire when heated, and burn with considerable splendour, but almost all of them may be burnt by peculiar contrivances. After combustion, their appearance is entirely changed; they have lost their metallic lustre, and are converted into *oxides*. Several of these are used as paints. By mixing these oxides with charcoal powder, and heating them, they may be restored to their original metallic state. But most of the metals are capable of combining with various quantities of oxygen, and of forming various kinds of oxides, known by different names; for instance, the *protoxide* (from the Greek *protos*, first; and the English *oxide*) of a metal, is the *first* oxide of it, or, in other words, it is the metal combined with the *least* portion of oxygen. The second, which has two equivalents of oxygen, is called a *deutoxide*, (from the Greek *deuteros*, second; and the English *oxide*) or *binoxide* (from the Latin *bis*, twice; and the English *oxide*.) The third, a *tritoxide* (from the Greek, *tritos*, third; and the English *oxide*) or *teroxide;* and so on, the highest degree of oxidation being termed the *peroxide* (from the Latin, *per*, very; and the English *oxide*) of the metal.

The *opacity*, *odour*, and *taste* of metals may be summed up in a few words. All the metals are perfectly opaque, except when reduced to extremely thin leaves, in which state some of them—gold-leaf for instance—are *semi-translucent* (or half-transparent, *i.e.*, imperfectly transmitting light: from the Latin *semi*, half; *trans*, through; and *lux*, light). The greater number of them are without *odour;* but tin, copper, iron, and lead, when rubbed, exhale an unpleasant smell, quite perceptible in workshops. Arsenic and antimony, when heated or vapourized, yield a peculiar odour. The metals are without *taste*; yet some (tin and

iron, for examples) have a singular and disagreeable flavour.

Platinum, gold, silver, mercury, copper, nickel, iron, and a few others, are occasionally found in nature perfectly pure, or free from any foreign substance; these are then termed *native metals;* but the most general form in which the metals are met with is that of *ore*, which consists of the metal combined with oxygen, carbon, sulphur, phosphorus, and other substances. When in combination with phosphorus, it is called a *phosphuret*; when with sulphur, a *sulphuret;* when with carbon, a *carburet;* and when with oxygen, an *oxide*. When two or more metals occur in combination with each other, they are termed a *native alloy* (osmium and iridium are always found in this state); but, when mercury is one of them, the compound is not called a native alloy, but a *native amalgam;* the only native amalgam known is that of mercury in combination with silver.

CHAPTER III.

ALLOYS.

THEIR HARDNESS.—SONOROUSNESS.—MALLEABILITY.—DUCTILITY.—FUSIBILITY AND DENSITY.—BRASS, BRONZE, AND BELL-METAL.

When two or more metals form either a natural or artificial compound, the term *alloy* is given to the mixture; but when mercury is one of the ingredients, the compound is termed an *amalgam.*

Arsenic occurs combined with antimony, bismuth, cobalt, iron, nickel, and silver. Antimony is found alloyed with cobalt and nickel: there is also a native alloy of antimony and nickel. The *natural alloys* are seldom, if ever, applied to any useful purpose; the only one of any importance is that of iron and nickel, constituting meteoric iron. The knives of the Esquimaux are made of this substance. The *artificial alloys* are of the greatest importance for manufacturing purposes, and also for the uses of every-day life, even more so than the metals themselves. Platinum is always employed in a pure state, and some metals, as copper, iron, lead, and zinc, are mostly so used. Antimony and bismuth *are alloyed* because they are extremely brittle. Gold would

not be so durable, either for coin or ornament, were it not alloyed with copper; and silver, though harder than gold, would not be of so much service if it were not mixed with copper. Zinc is sometimes, as in brass, alloyed with copper, to improve its hardness and colour.

Bismuth and zinc do not combine with each other, but most metals, by fusion, may be made to unite together, forming a compound dissimilar, in many of its properties, to either of its constituents.

An alloy is opaque, possesses metallic lustre, and conducts heat and electricity, like one of the metals, but generally differs from its constituents in colour, hardness, sonorousness, malleability, and ductility. The well-known *yellow* alloy *brass*, is a compound of copper, which is *red*, and zinc which is *white*. *Hardness*, and consequently *sonorousness*, are generally increased by alloy; the varieties of bell-metal are all alloys. *Malleability* and *ductility* are mostly impaired by alloy. Alloy favours brittleness; that of two brittle metals being *always*, that of a brittle and ductile metal *generally*, and that of two ductile ones *often*, brittle.

Fusibility.—The fusing-point of a mixed metal is generally lower than that of the most fusible metal of the alloy.

Density.—The following table shews where the density is increased, and where diminished by alloy:—

INCREASED.		DIMINISHED.	
	Alloyed with		Alloyed with
Antimony, Bismuth, Cobalt, Tin, Zinc	Gold.	Copper, Iridium, Iron, Lead, Nickel, Silver	Gold.
Antimony, Bismuth, Lead, Tin, Zinc	Silver.	Antimony, Bismuth, Lead	Iron.
Antimony, Bismuth, Palladium, Tin, Zinc	Copper.	Antimony, Lead, Palladium	Tin.
Antimony, Bismuth	Lead.	Copper	Silver.
Platinum	Molybdenum.	Arsenic	Nickel.
Palladium	Bismuth.	Zinc	Antimony.

The properties of the metals are not only altered by combination, but different proportions of the same metals produce very different alloys. For examples:—*Bronze*, which is an alloy of 90 parts of copper with 10 parts of tin, has greater density, hardness, and fusibility than the mean of the metals; the density and hardness of copper being increased by combining with a lighter and softer one; while, as we might expect, the fusibility of the more refractory metal is increased by uniting with one more fusible. And in *Bell-metal*, which is an alloy, consisting of 80 parts of copper and 20 parts of tin, the copper is made more sonorous by mixing it with a metal which is less so.

The formation of alloys, and the changes which the metals undergo, evidently arise from chemical affinity and action, for if these be wanting the metals cannot be combined, as is the case with bismuth and zinc.

CHAPTER IV.

ALUMINIUM,

(Called, by some, Aluminum.)

The first metal to which we invite attention is known by the name of "Aluminium," or, as some metallographers call it, *Aluminum*. It was discovered by Wöhler, in the year 1827, in alumina, which, next to silicon, is the most abundant of all the earths, and which enters into the composition of several of the rocks and strata forming the largest mountain chains.

Alumina is very seldom found pure in nature, but it may be procured in a perfect state of purity by dissolving common alum with carbonate of ammonia; it emits a peculiar odour when moistened, forms a paste with water, is adhesive to the tongue, has great affinity for colouring matters, will contract in the fire, and acquire greater hardness as the temperature is increased; and is soluble in most of the

acids. It is exactly twice as heavy as water; hence we say it has a specific gravity of 2. Common clay is a mixture of alumina and silica; but it very frequently contains metallic acids, chalk, and other earths. Alumina enters into the composition of all clays or *argillaceous* earths. *Argillaceous* is a term descriptive of those earths which contain alumina or clay. Several mineralogists seem to think that the peculiar smell which always shows its presence may be attributed to the presence of oxide of iron. Alumina, in combination with the oxides of iron, occurs in great abundance in Staffordshire and Derbyshire; in this state it is known as *raddle*, an article very useful in colour-making. It possesses an affinity for greasy substances, which makes it very useful in cleaning cloth, &c., and in taking out spots of grease from tables, floors, &c. *Fuller's earth*, a well-known soft, unctuous, opaque, and earthy substance—is composed of 50 to 55 per cent of silica, 10 of alumina, 10 of oxide of iron, 20 to 25 of water, with small proportions of lime, magnesia, and other matters. It occurs in beds among primary rocks in many countries, and abundantly in many parts of our own, as Bedfordshire, Buckinghamshire, Kent, Surrey, &c.

Alumina enters largely into the composition of those tenacious earths known as *arable* soils. It is found also in a state of crystallization in the sapphire, ruby, corundum, turquoise, topaz, and other precious stones.

It would be absurd for us to attempt to enumerate all the uses to which alumina has been applied in the arts, but we will merely mention one or two of the principal. In a state of *common clay* it is frequently employed without any previous preparation whatever, just as it comes from the bowels of the earth, for various purposes, on account of its being easily moulded into different shapes, and hardened by the action of the fire, such as for making bricks, crucibles, porcelain, earthenware, &c. In the Old Testament we find that earthenware was known to the Jews at an early period of the world's history; in all probability, the potter's wheel there spoken of was the same simple machine that is now employed in forming round vessels with plain surfaces. The Chinese and Japanese seem to have known how to make *porcelain* a long time ago. Dr. Thompson informs us that "it was accidentally discovered in Europe by Reaumur, a celebrated chemist, in the beginning of the

18th century." It appears that a missionary in China, named Entrecollas, forwarded to Reaumur a description of the process by which the Chinese made their porcelain; and having tried several experiments upon the materials used, he at last succeeded in producing porcelain similar to that made in China. Dr. Thompson (in the second volume of his works, page 286) also tells us that "it was so esteemed by the Romans, that after the taking of Alexandria, a porcelain vessel was the only part of the spoil retained by Augustus."

We will not make any further remarks upon alumina, although enough might be said to fill a huge volume. The subject belongs more to mineralogy than to metallography, and we should not have dwelt so long upon it, but this earth is the only known oxide of the metal aluminium.

Well, then, as regards *aluminium* (the metallic base of this earth), which exist in nature in granite, slate, schist, and a number of clays. The heavy clay lands of our country are, in fact, mines of aluminium, and the skill of the chemist only is required to extract from them this useful metal. Although Wöhler was the discoverer of this metal, he was only able to obtain it in the form of a grey powder. The discovery remained in this state until 1854, when Deville, of Paris, by means of a greatly improved process, was enabled to procure the metal in any quantity; so that now, instead of Wöhler's grey powder, aluminium is known as a metal possessing great brilliancy, ductility, and tenacity. Its fusing point is a little lower than that of silver; and when fused (or melted) it has all the necessary qualities for producing castings of the highest excellence—added to which, its non-tarnishing property, which is possessed by all its alloys, renders it admirably suitable for works of art. Two groups, being very clever pieces of workmanship, were exhibited in the International Exhibition of 1862, by Mr. John Hancock, a well-known and distinguished naturalist of Newcastle, by whom they were modelled and wrought, which furnish abundant proof of the perfect adaptability of this metal to the purposes of the founder. They were each cast in one piece of aluminium. Being one of the most sonorous of the metals, and its non-tarnishing property, make aluminium very serviceable in the manufacture of bell-metal. It has a fine white colour, slightly inclining to blue, especially after being well hammered. When cold,

like silver, it is susceptible of a very fine matting, is easily burnished or polished, and readily drawn into wire. It has been stated that its malleability is such that it can easily be beaten out, either hot or cold, to the same extent, and as perfectly as gold or silver. It is lighter than most of the metals, its specific gravity being only 2·6. Its elasticity and tenacity are both about the same as those of silver; and on account of its being readily fused, it is easily run into sand and metallic moulds. The alloy of aluminium with copper is one of great beauty, resembling the finest gold in both its colour and general appearance, with the advantage of being stronger than the best iron.

The manufacture of aluminium, as well as the alloy of this metal with copper, which we have just mentioned, has engaged the attention of Messrs. Bell, Brothers, very large ironmasters and manufacturing chemists of Newcastle-on-Tyne, who, as we understand, after much perseverance and expense, are now prepared to furnish it in any quantity.

One of the chief objects which we had in view in visiting the International Exhibition of 1862, was to view the large collection of minerals and metals; and we must confess, we were exceedingly interested with the large case exhibited by these extensive manufacturers, illustrative of the various qualities of this comparatively new metal, besides some artistic productions of great merit and beauty. And we trust that we, as a nation, shall not forget that we are largely indebted to the perseverance of the Messrs. Bell for the possession of this beautiful metal, which, on account of its valuable properties and the success which has attended the strenuous efforts of those manufacturers, bids fair to become one of the most useful and largely employed of the metals. Its lightness (its specific gravity being only one-fourth that of silver), and its freedom from corrosion, will, we are persuaded, insure for it an extensive application for philosophical instruments, reflectors, chemical weights, frames for *cartes de visite*, and an almost innumerable number of other articles.

CHAPTER V.

ANTIMONY.

THE ancients were not acquainted with Antimony as a metal, but they knew its oxide, which is termed by Pliny *stibiund*, as being found with silver. It appears to have been discovered in the year 1490, by Basil Valentine, one of the alchemists, a monk of Erfurt, who, it is said, after having found that it fattened some pigs to whom he had given it, was induced from this success, to try the experiment on some of his brother monks; and instead of the monks getting fat, as he expected, they died. Hence, some writers suppose that the name of the metal is derived from the Greek, *anti* (against or contrary to), and the French, *moine* (a monk).

Antimony ore is found in Sweden, Norway, Hungary, Bohemia, Saxony, Spain, France, Siberia, Borneo, Mexico, and in Cornwall and Ayrshire in Great Britain. The metal occurs in nature, in combination with sulphur; this sulphuret, which is the most common ore, may be made to yield the metal readily by heating it with iron, which retains the sulphur. The sulphuret is called *crude antimony*, to distinguish it from the pure metal, or *regulus of antimony*. It is composed of 75 parts of antimony, and 25 parts of sulphur, in 100. This ore, which is the only one found in sufficient quantity for the manufacturer, is purified by exposure to a strong heat in a reverberatory furnace; by this operation the pure sulphuret is separated from the earthy matter; this sulphuret is afterwards re-melted, and cast into cakes for sale. Antimony is also found occasionally mixed with oxygen, and often in a native state. Hungary and Borneo supply the largest quantities of the sulphuret. The oxide is met with in Saxony. A combination of antimony, oxygen, and water, called *antimony-ochre*, is found in Cornwall.

It is an extremely brittle metal, of a silver-white colour, a strong metallic lustre, and a *laminated* [from the Latin,

lamina, a plate, arranged in plates or scales] or striated texture. [*Striated*, from the Latin, *stria*, a streak—marked with *striæ* (fine thread, like lines or streaks) running parallel to one another]. When exposed to the air, at the ordinary temperature of the atmosphere, it becomes tarnished, but not oxidized; if, however, it be kept under water, it will remain unaltered. At a red heat, it decomposes steam with such rapidity, that a violent explosion or *detonation*, as it is termed [from the Latin, *de*, from, and *tono*, I thunder], is produced; the oxygen of the water forming an oxide with the metal, and the liberated hydrogen burning. At a temperature of 840 deg., Fahrenheit's thermometer, it melts; and on cooling, it crystallizes in the form of pyramids. It requires a much greater heat to volatilize it; it is also susceptible of vitrification, and produces a hyacinth-coloured glass. *Vitrification*, or *vitrifaction* [from the Latin, *vitrum*, glass, and *facio*, I make], is the process of converting into glass by heat. The word *thermometer* is derived from two Greek words, *therme*, heat, and *metron*, a measure; it is applied to an instrument for measuring the heat or temperature of bodies, by the regular expansion of mercury in a glass tube. The thermometers usually employed are Fahrenheit's, the Centigrade, and Reaumur's. The space between the freezing and boiling points of *Fahrenheit's* thermometer is divided into 180 deg., the freezing point being marked at 32 deg., and the boiling point at 212 deg. This space in the *Centigrade* thermometer is divided into 100 degs., and in *Reaumur's* into 80 deg. Hence 5 deg. of the Centigrade or 4 deg. of Reaumur's thermometer, are equal to 9 deg. of Fahrenheit.

The ductility of antimony is inconsiderable; its tenacity is such that a wire of one-twelfth of an inch in diameter will support a weight of 9 pounds; and its specific gravity is 6·702. Though it appears to be hard, it may readily be cut with a knife; it has a singular taste, and when rubbed it emits a peculiar smell. It is a bad conductor of heat and electricity.

Antimony combines with oxygen in three proportions, forming the gray, the white, and the yellow oxides of this metal. The *gray*, or *protoxide*, may be obtained by dissolving the metal in muriatic acid, and *diluting*, or rendering

more liquid, [from the Latin, *diluo*, I wash away], the solution with water, which will occasion this metallic oxide to *precipitate—i.e.*, to fall to the bottom from the solution [from the Latin, *præceps*, headlong] in combination with a small proportion of muriatic acid, from which it may be separated by boiling the precipitate—*i.e.*, the substance thus thrown down—in a solution of carbonate of potash. The protoxide thus obtained is a gray or rather dirty white powder, consisting of 81·5 antimony, and 18·5 oxygen. The *white*, or *deutoxide* of antimony, which is obtained by various methods, was formerly called *argentine flowers of antimony*; it is now termed *antimonious acid*, it having the property of uniting with salifiable bases, and forming salts with antimonites. *Salifiable* [from the Latin, *sal*, salt, and *fio*, I become] is a term applied to those bases which are capable of forming salts by combining with an acid. The *yellow*, or *peroxide* of antimony may be procured by dissolving the metal in nitric acid, and then drying the white powder which results by a heat insufficient to separate the oxygen. The solutions of the oxides of this metal are very powerful, and in some cases even poisonous when taken internally, except in very small quantities. By mixing the oxides of antimony in different proportions, various colours may be produced.

This metal may also be combined with chlorine, iodine, phosphorus, and sulphur. If it be ground into a fine powder and thrown into a dry glass jar, filled with chlorine gas, it will ignite instantaneously, and continue to burn with great rapidity, and with a brilliant white flame, forming a beautiful spectacle; *chloride of antimony*, formerly known as *butter of antimony*, is thus formed, which consists of 54·88 antimony, and 45·12 chlorine. It may also be obtained by distilling a mixture of one part antimony with two parts of corrosive sublimate. It occurs native in Bohemia. [To *distil* (from the Latin, *dis*, from; and *stilla*, a drop) is to let fall in drops, or rather to separate a lighter fluid from another by heat or evaporation, the vapour being cooled, and falling in drops into a vessel placed to receive it.]

Iodine of antimony is prepared by heating the two substances together. It is a compound of a dark-red colour. Phosphorus and antimony may be united by fusion; but

the compound, which is a brittle substance, possessing metallic lustre, is not a very useful body. This metal may also be united to sulphur by fusion. The substance formed has a metallic appearance, and very much resembles the native sulphuret of antimony.

As a medicine, antimony occupies a very high position among the metals. Some of its preparations act as very powerful emetics and cathartics, whilst in the crude state, it is quite harmless to the human constitution. In several kinds of disease it is considered as a very valuable remedy; indeed some of our most eminent chemists of the present day have asserted that perhaps we have no metal more valuable as a medicine than antimony, and yet, as one writer justly observes, no medicine has ever undergone such vicissitudes in refutation.

The well-known white powder, termed *James's Powder*, is a phosphate of lime and antimony, or, in other words, a salt consisting of phosphoric acid combined with those substances. *Emetic tartar* consists of about fifty-six parts tartrate of antimony, thirty-six tartrate of potash, and eight of water. A *tartrate* (from the English, *tartar)* is a neutral compound of tartaric acid with a base. Chemists apply the word *neutral*—which is derived from the Latin, *ne*, not; and *uter*, either of the two—to those salts which are composed of an acid and a base in such proportions that they exactly destroy each other's properties. The sulphuret, and some other preparations of antimony, which act as alteratives, and may generally be depended upon for the certainty of their effects, are given to cattle more than any other medicine. *Antimonial wine* is tartrate of antimony dissolved in water.

But antimony is employed for many other purposes. Mixed with lead, in the proportion of one part of antimony to sixteen parts of lead, and a little copper or tin, it forms the very important alloy, *type-metal*, which is of very great value in taking exceedingly sharp impressions from the matrix or mould, as it expands immediately it becomes solid, giving to the letters great firmness and smoothness. Equal quantities of antimony and copper fused together, produce a most beautiful violet-coloured alloy, which was formerly termed *regulus of Venus*.

Pewter is an alloy of antimony and tin. Antimony is

used in the manufacture of small shot; also as an ingredient in concave mirrors, and specula for telescopes, and in plates upon which music is engraved. It is employed in casting cannon balls, as it promotes the fusion of nearly all other metals, and in the casting of bells to make them harder, and to give them a clearer and stronger sound. It is likewise used in giving a yellow colour to glass and earthenware. Eight parts of antimony, 100 of tin, 2 of bismuth, and 2 of copper, constitute *Britannia-metal*, of which spoons and tea-pots are frequently made.

In times of remote antiquity, a preparation of antimony was employed by females as a black pigment for staining the eyelids. Jeremiah and Ezekiel allude to this practice in their writings (see Jeremiah iv., 30; and Ezekiel xxiii., 40). This custom is still kept up by the women of the East. The Arabic name of one of the preparations of antimony used for this purpose is *kohol*, which, with the article *al*, is the origin of the term *alchohol*, now applied to spirits of wine.

CHAPTER VI.

ARSENIC.

Arsenic, or some of its native combinations, was known to our forefathers more than 1,800 years ago, but no one was acquainted with its physical properties until the year 1733, when the metal was obtained from the white oxide, and investigated in a philosophical manner by Brandt. It exists native, and in combination with oxygen, with sulphur, and with most of the metals. *Native arsenic* occurs as a greyish, black, dull substance externally, and of a lead-grey, inclining to the colour of tin, inwardly, in veins in primitive rocks, as in gneiss, mica slate, and clay slate, and less often in transition and secondary rocks in Norway, Germany, France, Spain, Bohemia, and America. It is worthy of

observation, that though its form is irregular, yet, internally, cavaties are found in it having the forms of the cube and octohedron. When newly broken it possesses great metallic lustre, but soon becomes black if exposed to the influence of the atmosphere. It yields a white smoke before the blow-pipe, having an arsenical odour.

Arsenic has also been met with in veins of mountains in several localities in Europe, accompanying cobalt, copper, iron, silver, and several other metals. It is found in Germany chiefly combined with cobalt ores. Arsenic is also united with, and contaminates several of the other metallic ores, in England.

Arsenical pyrites, from which the white oxide is obtained, occurs abundantly in Cornwall and Devonshire; it is also found at Alva, in Stirlingshire; and in Norway, Sweden, Bohemia, Hungary, Saxony, and other localities on the Continent.

There are two *sulphurets of arsenic*. The first, consisting of 65 parts (in 100) of arsenic and 35 parts of sulphur, and known by the name of *realgar*, is of a scarlet or dark orange colour, tasteless, and not so poisonous as arsenic itself. It is met with in Bohemia and Saxony, and is much used as a pigment, and in the manufacture of fireworks. The second sulphuret contains about 58 per cent. of arsenic, and 42 per cent. of sulphur; it is called *orpiment*, and is found in Hungary, China, and South America. Realgar is always found in primitive mountains, whereas orpiment generally occurs in secondary mountains. Orpiment may be formed artificially by pouring a solution of sulphuretted hydrogen into water in which arsenic has been dissolved; it possesses a fine lemon colour, and is largely employed in dyeing and calico-printing. The pigment called *king's yellow* is made from yellow orpiment. Both king's yellow and the white oxide of arsenic are used in colouring glass; but glass prepared with any of the compounds of arsenic, in large quantities, should never be used for domestic purposes.

Arsenic, in its pure metallic state, is a metal of a greyish white colour and strong metallic lustre, somewhat resembling polished steel; but, if exposed to the atmosphere, it soon loses its brilliancy, becoming first yellow and afterwards almost black; it undergoes no change, however, when kept under water. It is, of all metals, the most

brittle, and may readily be pulverized by trituration in a mortar. If a piece of arsenic be broken, it exhibits a laminated texture. Besides being the most brittle, this metal is, at the same time, one of the softest of that class of elementary substances to which it belongs. Arsenic has no smell while cold, but when heated to 356 degrees Fahrenheit, it becomes volatilized without being melted, the vapour possessing a strong smell not unlike that of garlic, and proving exceedingly poisonous, when inhaled, even in the minutest quantity. When sublimed, it is converted into the protoxide which crystallizes in tetrahedrons. If its crystals be heated without the contact of the atmosphere, they immediately change into a colourless gas, which condenses again into crystals. If a piece of arsenic be thrown upon hot iron, it will ignite and burn with a blue flame and a dense whitish smoke, emitting a very strong powerful odour resembling that of garlic. The specific gravity of arsenic is about 5·884; some, however, make it only 5·682.

Oxygen and arsenic very readily unite with each other. Two combinations of these bodies are known; namely, *arsenious acid*, and *arsenic acid*; the former, which is the *white arsenic* of commerce, may be produced by exposing the metal to a moderate heat, by which it is volatilized, united with oxygen, and converted into the *white oxide*; it is a hard, brittle substance, with a glassy texture. Notwithstanding this acid is one of the most virulent poisons; when administered judiciously in small doses, it is a medicine of great value for certain complaints, such as ague, for example, forming, as it does, a notable ingredient in what are termed *ague-drops*. By mixing this oxide with black flux, and exposing it to heat, it may be again reduced to a metallic state. It is a compound of 75·2 arsenic, and 24·8 oxygen; its specific gravity varies from 3·7 to 5. It is very readily soluble in water—in fact, remarkably so. Its taste is acrid and sweet; it sublimes at 383 degrees Fahrenheit, and it crystallizes in tetrahedrons. It destroys the magnetic property of all the metals which are susceptible of that property.

This oxide is chiefly obtained from the cobalt works of Bohemia and Saxony, where *zaffra* is made; cobalt ores containing a large proportion of arsenic. It is originally

prepared in cakes, brittle, white, rather sweetish in taste, and more or less translucent; these cakes undergo sublimation, when intended for medicinal purposes, in order that the arsenious acid may be separated from the sulphur or other impurities which the cakes may contain. It is generally sold by chemists in the form of a white, gritty powder.

Arsenic acid, the *peroxide* of arsenic, which, according to the manner in which it is prepared, is either in the form of a white solid mass or of the consistence of jelly, was, it is said, first known to Scheele; it contains 65·4 per cent. of arsenic, and 34·6 per cent. of oxygen. It may be procured by dissolving the white oxide in nitro-muriatic acid, evaporating to dryness, and applying sufficient heat to drive off the acids. Thus obtained, it is a white, solid mass, almost tasteless, slowing dissolving in cold, but rapidly in warm water, and having a specific gravity of 3·391. When melted at a red heat it is converted into glass. It possesses all the properties of an acid, and, like arsenious acid, is very poisonous.

Arsenic may be united with so large a proportion of oxygen as to become changed into a perfect acid. Arsenic, chromium, columbium, molybdenum, and tungsten (?), are the only metals, we believe, which are completely acidifiable.

This metal may be also combined with hydrogen, with chlorine, with iodine, with phosphorus, and with sulphur (as we have noticed before). Hydrogen and arsenic, when united, form a permanently elastic and invisible fluid, somewhat lighter than atmospheric air, and known as *arsenuretted hydrogen gas*. This gas has a fœtid smell; it is incapable of supporting combustion, and consequently would destroy animal life. It is in itself combustible. Arsenic, when combined with chlorine gas, burns with much brilliancy, and the result is *chloride of arsenic*. Phosphorus and arsenic readily combine, and form together a brilliant black powder. Sulphur and arsenic speedily unite, when fused together, and form a red, vitrious, semi-transparent mass, which is a true sulphuret of arsenic, and is known as *realgar* (the composition of which has already been given). The ancients used a sulphuret of arsenic, both as a medicine and a paint; *sandarache*, mentioned by Aristotle in his writings, was a sulphuret of this metal. The term *arsenicon*,

signifying "masculine" (no doubt conferred on the mineral on account of its powers), appears to have been first used by Dioscerides at the commencement of the Christian era.

Although *chloride of arsenic* was made by the old chemists, and was known by them as *butter of arsenic*, yet the salts which have been formed with this metal are few. *Arsenite of potash* may be procured by boiling caustic potash with white arsenic—the white oxide of arsenic, or, more accurately, arsenious acid. The *arsenite of soda* may be prepared in a similar manner. Several arsenites may be obtained by double decomposition: for instance, the *arsenite of copper* may be formed by adding a solution of sulphate of copper to one of arsenite of potash; and the *arsenite of lead* by merely mixing a solution of nitrate of lead with a solution of arsenite of potash. None of the salts of arsenic (considered as a base) have been found native; but we are acquainted with a large number of native salts in which arsenic occurs as an acid; among others may be mentioned the arsenites of cobalt, copper, iron, and lime. Both the arsenious and the arsenic acids form salts with metallic oxides, the former with bases forming the class called *arsenites*, the latter *arseniates*.

Most of the other metals may easily be alloyed with arsenic; it certainly promotes their fusibility, but it destroys their malleability and renders them brittle, even in very small quantities; hence, how necessary it is, in the reduction of their ores, to free the metals from every particle of arsenic! This metal occurs in a very large number of natural alloys, but, fortunately, the property which arsenic possesses of easy volatilization, greatly facilitates its separation from other metals.

Arsenic is employed to whiten copper. Alloyed with copper, it forms a malleable and flexible alloy, which takes a fine polish, and is therefore of great use for specula of reflecting telescopes, and other optical instruments. Arsenic is also used in making small shot, because it renders the lead more brittle, and better capable of granulating. Its oxides are used in many processes by the dyer, besides as fluxes for glass, and in several of the arts. Its sulphurets form valuable pigments of different colours, and are largely employed in calico-printing, on account of its property of deoxidizing indigo, and thereby rendering it soluble in an alkali.

This metal, upon the whole, is perhaps one of the least useful to man of all the metallic substances which he has discovered.

In its pure metallic state, arsenic has little effect upon the system; but when combined with oxygen it becomes a virulent poison.

CHAPTER VII.

BARIUM.

The next metal which claims our attention, is known by the name of Barium. Barium was first known by Sir Humphrey Davy, who discovered it in the year 1807. It is the basis of an alkaline oxide or earth called *barytes*; this earth, also known as *baryta*, was so named from the Greek adjective *barys* (which signifies heavy), on account of its great density. It may be procured by strongly heating baryta in an iron tube, through which the vapour of potassium is conveyed; the barium can then be extracted from the oxide of potassium by amalgamating it with mercury, which may afterwards be driven off by means of heat. It is a malleable metal of a yellow colour. When exposed to the atmosphere it gradually absorbs oxygen from it, and becomes covered with a thin coating of baryta. If it be moderately heated, in contact with the air, it burns with a deep blue flame; it melts below a red heat, and is volatilized at the highest possible temperature. It rapidly decomposes water, giving out hydrogen, and is converted into baryta. It is between four and five times as heavy as water, and has been employed in the manufacture of certain kinds of glass.

Barium and oxygen unite in two proportions.

The *protoxide of barium*, *barytes*, or *baryta*, is very abundant in nature; it is usually found mixed with carbon and sulphur, forming the veinstone in several lead mines.

It frequently occurs in combination with sulphuric acid; in this condition, it has been stated, baryta was discovered by Scheele, in 1774, in a mineral called *ponderous spar* (*terra ponderosa*), or *baroselenite*. It generally occurs in this state in England, and several other parts of the earth. In the county of Derby, it is properly called *cauk*. But baryta has also been met with in large masses in many parts of Great Britain in combination with carbonic acid. It is generally found in France, united with the oxide of manganese. *Pure baryta* has a greyish-white colour, and a pungent, caustic taste. It has the property of enabling oil to unite with water. When exposed to the atmosphere, it swells like quick-lime, and like it falls into a white powder, but this slaking is much more violent and speedy than that of lime. It unites intimately with water, by which combination the water becomes solidified. It changes the vegetable blues like alkalies; and is, in all its combinations, a most virulent poison. Baryta may be known from the other earths by its solubility in water, by its forming an insoluble compound with sulphuric acid, and by its tinging flame yellow. The solution of this earth in water, and in various acids, furnishes some of the most excellent tests for chemical analysis. Boiling water will dissolve half its weight of baryta, part of which will crystallize on cooling. Dissolved in muriatic acid, it is sometimes employed as a medicine. Baryta is capable of making a very tenacious cement, but has not yet been used largely in the arts; it has, however, been made use of by artists as a most excellent water-colour, because it is, we believe, the only white for water-painting which never changes, and which may be mixed with any other colour without injury. It is sold under the name of *Hume's permanent white*. Baryta is a non-conductor of electricity, and has a specific gravity of 4·000.

The *binoxide*, or *peroxide*, of barium may be obtained by exposing baryta, heated to redness in a porcelain tube, to a current of pure oxygen gas. This oxide is of a grey colour, and is composed of 1 equivalent of barium, to 2 equivalents of oxygen.

Sulphate of baryta, or *heavy spar*, is often found in nature beautifully crystallized. It is largely used as a pigment. The native salt is first finely pulverized, and

then washed with diluted sulphuric acid, by which its colour is greatly improved. Its specific gravity is 4·500.

The *natural carbonate of baryta*, called *witherite*, is a heavy white powder, and very sparingly soluble in water.

Barium is not so valuable to man as many of the other metals, because all its preparations are exceedingly poisonous.

CHAPTER VIII.

BISMUTH.

Bismuth, a much longer known and more useful metal than that which has just occupied our attention, appears to have been first known by Agricola, about 1530; but Stahl and Daufay were the first who recognised it as a peculiar metal. It has been found mostly native (but mixed with a very small portion of cobalt or arsenic), often in combination with sulphur, and seldom with oxygen, in Cornwall, France, Saxony, Bohemia, Sweden, and Transylvania. It has likewise been met with, crystallized, in the veins of mountains, accompanying the ores of nickel, lead, and occasionally those of silver.

This metal may easily be separated from its ores, on account of its great fusibility, by subjecting them, in iron tubes, to the heat of a furnace; the tubes being inclined so that the bismuth may run out at one end as it melts.

It is a reddish-white metal, of considerable metallic lustre, of a lamellated texture, having little taste or smell, a specific gravity of 9·83, and a fusing point of about 476 degs. of Fahrenheit; when allowed to cool slowly, after fusion, it crystallizes in cubes and parallelopipeds. It is scarcely, if at all, malleable, being so brittle that it breaks readily under the hammer, and may even be reduced to powder; nor can it be drawn into wire; and its tenacity is such that a rod one-tenth of an inch in diameter will support a weight of about 30lb. In hardness it is intermediate between gold

and silver. When exposed to the influence of the air at the common temperatures of the atmosphere, it loses its lustre, but does not become oxidized; it may, however, be kept unaltered when immersed in water. If this metal be subjected to a strong heat, it ignites, burning with a small blue flame: a yellow smoke arises (known by the name of *flowers of bismuth*), which, when condensed, forms the *yellow oxide*, or *protoxide of bismuth*. It consists of 89·4 bismuth, and 10·6 oxygen; and, being insoluble in water, is consequently tasteless. When heated, this oxide is converted into brown glass. *Peroxide of bismuth* may be procured by heating the protoxide with a solution of chloride of lime; it possesses a dark-brown colour, and its appearance reminds one of the peroxide of lead, which it very much resembles. If it be heated to about 600 degs., it becomes converted again into the yellow oxide.

As it possesses the singular property of expanding as it cools, bismuth is of great value in the composition of the type of the printer; as from this expansive property are obtained the most perfect impressions of the moulds in which the letters are cast. As it communicates fusibility to most of its alloys, it is employed as an ingredient in the *solder* used by pewterers, which consists of 1 part of bismuth, 5 parts of lead and 5 of tin. Bismuth enters into the composition of some kinds of pewter. Equal weights of bismuth and lead form a brilliant white alloy, harder than lead, and tolerably malleable. *Newton's fusible metal*, which is so called from its discoverer, and which fuses below the heat of boiling water, and may be melted in a piece of stiff paper, over a candle, without burning the paper, is composed of 8 parts of bismuth, 5 of lead, and 3 of tin; it fuses at 212 degs. Fahrenheit. *Rose's alloy*, which melts at 201 degs., is formed of 2 bismuth, 1 lead, and 1 tin; such also is the alloy known by the name of *Arcet's fusible metal*. Bismuth renders platinum, gold, silver, copper, and iron brittle. It may easily be amalgamated with mercury; when there is not so much bismuth as mercury, the amalgam is fluid, and possesses the property of rendering lead likewise liquid. Bismuth will not unite with zinc. If potassium and bismuth be combined, an alloy is formed which, when put into water, causes hydrogen to be evolved, and potash is formed and dissolved. Sodium and bismuth produce a somewhat similar

alloy. The alloy used for the silvering (as it is termed) of the inside of glass globes, consists of 2 parts of bismuth, 1 of lead, 1 of tin, and 4 of mercury; the inner surface of the globe is first well dried, a small piece of the alloy is then introduced, which melts on the globe being plunged into hot water, and by turning the globe about, the fluid alloy is spread over the inner surface of the glass. *Pearl-white* and *flake-white* are precipitates from solutions of salts of this metal, used as paints and cosmetics. Pearl-white is much used by ladies, as it imparts a beautiful white appearance to the skin; but it has the great inconvenience of becoming black, by the contact of gas which arises from the burning of mineral coal. A story is frequently told of an old lady, who, on visiting one of the watering-places in Germany, emerged from the bath as a "lady of colour;" this singular effect was produced by the chemical action of the mineral water, which turned almost to blackness the cosmetic containing bismuth, which the lady had previously applied to her face. Another anecdote is related of a lady of fashion, who having incautiously seated herself too near the fire at a quadrille-table, her countenance suddenly changed from a delicate white to a dark tawny, as though by magic. The surprise and confusion of the whole party had such an effect upon the disfigured fair one, that she was actually dying with apprehension, when the doctor or physician dispelled her fears by informing his patient that nothing more was necessary than for her to abstain from using mineral cosmetics, and to trust in future to those charms which nature had bestowed upon her. Pearl-white will also turn black when brought into contact with sulphuretted hydrogen gas or the fumes of fœtid substances.

Bismuth may readily be distinguished from most of the other metals, because *the nitrate* of this metal will not dissolve in water, like other metallic salts, but becomes, decomposed, forming one of the most delicate white precipitates that has yet been obtained. This precipitate, when washed and dried, is what has been called *magistery of bismuth*, or pearl-white, to which we have just alluded. This metal enters into the composition of two sympathetic inks, which are solutions of the nitrate and hydro-sulphuret of bismuth. Characters written or drawn with these inks are invisible when dry, but appear again on damping the paper, or on holding it over vapour of sulphur.

Many French chemists recommend the use of the oxides of this metal for dyeing, to fix certain particular colours. Pomatum containing the oxide of bismuth will turn the hair black. Bismuth is also sometimes, though very rarely, given in medicine.

None of the salts of this metal have been found in a native state.

CHAPTER IX.

CADMIUM.

A METAL very much resembling tin in its colour, brilliancy, softness, susceptibility of polish, and in the peculiar crackling noise which it emits when bent, was discovered by Professor Stromeyer, of Göttingen, in a preparation of zinc, from the manufactory of M. Hermann, in Silesia, in the year 1817, to which he gave the name of *Cadmium*, the common ore of zinc being formerly termed *cadmia fossilis*.

It possesses a compact texture, and at 62 degs. has a specific gravity of 8·604, which is increased to 8·694 after the metal has been hammered. It is soft, being readily bent, filed, or cut with a knife; and leaves a stain when rubbed on paper, or other substances, which very much resembles lead.

Dr. Wollaston's is, perhaps, the best way of obtaining cadmium; it is as follows:—From the solution of the ore, precipitate all other metallic impurities by a plate of iron; filter; and immerse a plate of zinc in a clear solution: if cadmium be present, it will be precipitated in the metallic state.

Like tin, this metal, by mere exposure to the air, is slowly acted upon, but it eventually loses its metallic lustre. It melts at 422 degs. Fahrenheit; after fusion, it crystallizes in octohedrons; and its surface, whilst cooling, has the appearance of leaves of fern. Below a red heat, it is transformed into a vapour, of no peculiar odour, which

condenses in small drops, like mercury, presenting a crystalline structure. When heated with access of atmospheric air, it burns, and, combining with oxygen, is converted into a yellowish-brown powder, consisting of 85·648 cadmium, and 14·352 oxygen; this is the only known oxide.

Cadmium unites with cobalt, copper, mercury, platinum, and zinc. The silver-white alloy of cobalt and cadmium, bears great resemblance to arsenical cobalt. Combined with copper, it forms a white alloy, slightly tinged with yellow, the texture of which is composed of very thin plates; *tutty* consists of 54·4 copper, and 45·6 cadmium. Mercury and cadmium readily combine cold, and form a silver-white amalgam, of a granular texture, which is composed of 100 mercury, and 27·78 cadmium, and has a fusing point of 167 degs. Fahrenheit. One hundred parts of platinum unite with 117·3 cadmium. Most of the alloys of this metal are brittle, and colourless, and when they are subjected to great heat the cadmium is volatilized.

Having been found only in small quantities, it is imperfectly known. It has been occasionally employed by dentists. The sulphate of cadmium has been used for removing spots from the eye. The yellow sulphuret forms an excellent paint. Cadmium is met with in Silesia, united with several ores of zinc, which contain from 2 to 12 per cent. of this metal; and it is also found in the Derbyshire silicates of zinc.

CHAPTER X.

CÆSIUM.

This metal, the name of which is derived from the Latin, *cæsius*, sky-blue, belongs to the same group of elements as lithium, sodium, potassium, and rubidium, and was discovered in the year 1860, by Kirchhoff and Bunsen, by the help of spectrum-analysis. Cæsium, like rubidium, was at first

only found in one or two mineral waters, but has since been shown to be widely distributed in the vegetable as well as in the mineral kingdom; it has been obtained in considerable quantities from the beet-root salt, and found in the ashes of tea and coffee—thus proving that it occurs commonly in soil; whilst, quite recently, M. Pisaini, has found that a mineral called *pollux*, occurring in Elba, contains 34 per cent. of cæsium, which metal was mistaken for potash in the analyses which had previously been made of this substance. The compounds of cæsium so closely resemble those of potassium and rubidium, that no difference can be perceived between them by ordinary artificial means; but by the spectrum it can be easily detected.

Cæsium was first discovered in the Dürkheim mineral water; it is also met with in the Kreuznach; but the most abundant source is in the lepidolite of Hebron in Maine, in the United States of America. For the extraction of cæsium from the lepidolite, we would recommend the following process:—Take 10 parts of the lepidolite in powder, passed through a sieve; mix with 40 parts of coarsely powdered quicklime; then take a quantity of water sufficient to slake the lime, and mix it with as much hydrochloric acid as will convert from 6 to 7 parts of the lime into chloride of calcium; unite the two mixtures, and stir vigorously during the slaking, so as to intimately blend the mineral with suitable proportions of dry hydrate of lime and chloride of calcium. This mixture should now be put into a Hessian crucible, and heated to redness for 6 or 8 hours: the product of this operation may then be detached from the crucibles, and boiled with water till all but a trace of the chlorides is removed. The solution thus obtained, containing chloride of calcium and alkaline chlorides, must now be evaporated till crystals begin to form. Sulphuric acid must now be added as long as sulphate of calcium separates, excess of acid being carefully avoided, and the whole mass evaporated to dryness and strongly heated, in order to expel free hydro-chloric acid. The residue can now be heated with water; the small quantity of sulphate of calcium which may pass into solution can be precipitated by carbonate of ammonium: the precipitate should then be filtered off, and the filtrate again evaporated to dryness and ignited. You will then have a mixture of chlorides con-

taining also small quantities of the sulphates of sodium, lithium, potassium, rubidium, and cæsium, from which the chlorides of rubidium and cæsium may be separated by treatment with bi-chloride of platinum, as directed by Bunsen.

Metallic cæsium has not yet been obtained, it can only be produced as an amalgam with mercury. Cæsium forms salts, chlorides, sulphates, carbonates, nitrates, and tartrates with platinum.

CHAPTER XI.

CALCIUM.

Sir Humphrey Davy, in the year 1808, decomposed that very useful, and generally known earth, commonly called *lime*, and separated its metallic base, to which he gave the name of *calcium* (from *calx*, the Latin term for lime). This he did by the means of voltaic electricity; having made carbonate of lime or chalk into a paste with water, and placed it on a plate of platinum, he made a cavity in the paste to receive a globule of mercury. He then connected the mercury with the negative extremity of the pile, and the positive wire with the platinum plate. In this way, the lime becoming decomposed, an amalgam, consisting of mercury and calcium, was formed. He then distilled this amalgam in glass tubes, filled with the vapour of naphtha.

Its physical properties are unknown, except that it is a white combustible metal, having the colour and lustre of silver.

Immediately that atmospheric air is admitted to calcium, it absorbs oxygen, and burns with an intense white light, and becomes converted again into lime, which is the *protoxide* of this metal.

Pure lime is tasteless, insoluble in water, consists of 100 parts of calcium and about 37·5 of oxygen; has a white colour, a hot caustic taste, and a specific gravity of 2·3; it is infusible, except by the voltaic pile, or the gas blow-pipe.

Lime readily absorbs water poured upon it, swells, produces great heat, bursts, and is converted into hydrate of lime, or *slaked lime;* this when mixed with silicious sand, and water added, constitutes *mortar*, a cement employed in building.

As it possesses the property of promoting the dissolution and putrefaction of all animal and vegetable substances; and of imparting to the soil a power of retaining a quantity of moisture necessary for the nourishment and vigorous growth of the plants, lime is largely used as a manure in agriculture. It is also employed by sugar-bakers, soap-boilers, tanners, bleachers, and others; and, likewise in medicine. This oxide has been known from the remotest ages, and is one of the most plentiful, and widely distributed substances in nature; always occurring in a state of combination either with carbonic acid, constituting *chalk, marble, limestone, calcareous spar, the shells of fish,* and *the eggs of birds;* with sulphuric acid, forming *sulphate of lime,* and *gypsum;* with phosphuric acid in *apatite,* and *animal bone;* with fluorie acid in the *fluor-spar*; or with silica and other earths, entering into the composition of many minerals and precious stones.

The *peroxide* of calcium consists of 100 metal, and 80 oxygen.

Calcium, being obtained with great difficulty, is applied to no particular purpose; indeed, by far the greater number of chemists have never even seen it.

When mercury and calcium are combined, an amalgam is formed which when thrown upon water, disengages hydrogen gas, and the water becomes a solution of lime.

CHAPTER XII.

CERIUM.

Messrs. Hissinger and Berzelius, having examined in 1804 an earth termed by Klaproth *orchroita,* declared it to be an oxide of a new metal, to which they gave the name

of *cerium*, after the planet Ceres, which was discovered about the same time. It was obtained from a peculiar mineral, found at Ridderhytta, in Westmannland, in Sweden.

On account of its scarcity, and from the difficulty of reducing its ores to the metallic state, the properties of cerium are unknown, except that it is a brittle metal, has a white colour, resembles tungsten in its appearance, with which it was at first confounded; and when intensely heated, it burns with a vivid flame, and is partly volatilized.

The following is Langier's process for obtaining the oxide of this metal, which has never been reduced to the metallic state:—The mineral cerite is dissolved in nitro-muriatic acid, a precipitate is produced by ammonia, which is well washed, and, while still moist, is treated with a solution of oxalic acid, which dissolves out the oxide of iron which had been thrown down; the remaining powder is, after calcination at a red heat, pure oxide of cerium.

There are two oxides of cerium known—the *protoxide*, which is *white*, and, according to Hissinger, composed of 85·17 metal and 14·83 oxygen; and the *peroxide*, which is *red*, consisting of 79·3 metal and 20·7 oxygen. According to the Swedish chemists, there are two oxides intermediate between these, the *yellow* and *brown*.

CHAPTER XIII.

CHROMIUM.

This metal derives its name from the Greek *chroma* (colour), was discovered by Vauquelin in some Siberian red-lead ore, in the year 1797. It has a greyish-white colour, and a specific gravity of 5·9; it is very brittle, capable of a high polish, requires a most intense heat to fuse it, and does not readilly enter into combustion. It is magnetic, though not so much so as iron, nickel, or cobalt. The mineral acids, the nitro-muriatic excepted, do not act upon it.

Chromium is not altered by exposure to atmospheric air, but when heated is susceptible of three degrees of oxidation. The *protoxide*, or *green oxide*, which may be obtained by exposing the metal to heat, or by heating chromic acids in close vessels, is infusible, indecomposible by heat, reducible by voltaic electricity, and not acted upon by oxygen or the air. The *deutoxide*, or *brown oxide* may be procured by exposing the protonitrate, or the protoxide dissolved in nitric acid, to heat till fumes of nitrous gas cease to ascend; a brown powder, insoluble in acids, and scarcely soluble in alkalies, remains. The *peroxide*, or *chromic acid* is found in nature in red-lead ore; it has a deep scarlet colour, and consists of one part chromium, and two parts oxygen.

The oxides of this metal furnish the most beautiful pigments used in oil and water-colour painting, dyeing, calico-printing, enamelling, and in glass and porcelain painting.

The principal ores of chromium are *chromate of lead*, found in the Ural Mountains, in Siberia, and in Brazil; and *chromate of iron*, found in France, in Shetland, and near Baltimore in America. It has never been found in the metallic state, but only in the state of oxide, or in that of an acid. It is supposed to be the colouring principle of the emerald and the ruby.

CHAPTER XIV.

COBALT.

Cobalt derives its name from *kobold* (an evil spirit), because, as it renders the working of metals with which it may be combined very difficult, the superstitious miners imagined that they were bewitched.

It has a grey colour with a tinge of red, a specific gravity of 7·834, a granular texture, and a fusing point of 130 degs. Wedgewood; it is sometimes composed of plates, sometimes of grains, and sometimes of very small fibres, adhering to

each other; it is attracted by the magnet, and may itself be converted into a magnet; it is so brittle that it may easily be reduced to powder. It is not very brilliant, and it undergoes but little change when in contact with the air, or with water, at ordinary temperatures; but, at a red heat in an open vessel, it becomes oxidized. The oxide furnishes all those beautiful blue colours employed in the manufacture of glass, porcelain, and pottery; it has such a power with vitrifiable substances, that 1 part in 240 will communicate a deep blue tint to glass.

Oxygen combines with cobalt in three proportions, forming the *protoxide*, the *deutoxide*, and the *peroxide*. The *protoxide*, which is *dark blue*, may be procured by igniting gently in a retort the oxide precipitated by potash from the nitric solution. It consists of 84·38 cobalt and 15·62 oxygen, and dissolves in acids without effervescence. Moist protoxide, when exposed to the air, gradually absorbs oxygen, and assumes an *olive* colour; this is the *deutoxide*, which is composed of 73 metal and 27 oxygen, or as Rothoff makes it, 100 metal + 36·77 oxygen. By gradual exposure of this oxide to the air, more oxygen is absorbed, and the *peroxide* is formed; this is *black*, and consists of 80 cobalt and 20 oxygen.

Zaffre is the term applied to a mixture of an impure oxide of cobalt and finely-ground silica, obtained by calcination of the ores. The oldest and the best-known *sympathetic-ink* is obtained by dissolving zaffre in nitro-muriatic acid. The solution is green, or if there be no excess of acid, blue; but it turns red when diluted with water. Landscapes drawn with it in this state, on paper, are colourless when cold, but acquire a fine green or blue colour (according to the quantity of acid), when heated or otherwise thoroughly dried.

Smalt is a finely pulverized deep blue glass, which owes its colour to the presence of oxide of cobalt. It is sometimes called *azure blue*; it is employed in washing to prevent linen from becoming yellow, and by paper manufacturers to give a blue tinge to writing and printing papers. Smalt is also used in porcelain, pottery, glass, encaustic tiles, fresco-painting, &c.

The peculiar properties of cobalt were discovered by Brandt, who first obtained it in the metallic state in 1733.

It is met with in nature associated with arsenic, copper, iron, nickel, and sulphur: and in the metallic state, it occurs in meteoric stones or Aërolites. It is found in Cornwall, and Somersetshire; Sweden yields a considerable quantity; but Saxony produces the most.

CHAPTER XV.

COLUMBIUM,

Tantalum, or Tantalium.

Columbium was first obtained by Mr. Hatchett, in the year 1801, whilst analysing a mineral, which had been sent from America, to Sir Hans Sloane, and deposited in the British Museum. He evidently derived the term which he applied to it, from *Columbus*, the name of the discoverer of that part of the world in which this mineral was found.

Not long after this, Ekeburg, a Swedish chemist, discovered in a mineral from Finland, a metallic oxide, the base of which he called *Tantalum*, from the name of the mineral itself. Dr. Wollaston having examined this substance, found it to be identical with Hatchett's columbium.

Columbite, or *tantalite* (as it is frequently termed), the ore of columbium, first discovered in Connecticut, and occurring also in Finland, is an iron-black, brittle mineral, usually associated with beryl, and consists chiefly of columbic or tantalic acid and peroxide of iron and manganese.

The following is Dr. Wollaston's method for obtaining the oxide of this metal, from tantalite:—Mix one part of tantalite with five parts of carbonate of potash and two of borax, and fuse in a platinum crucible; soften the mass with water, and digest it in hydrochloric acid. The iron and manganese are dissolved, and a white powder remains, which is the oxide of columbium.

Berzelius, by exposing this oxide, mixed with charcoal, to an intense heat, deprived it of its oxygen, although he was

unable to melt it. The metal had a dark-grey colour, was brittle, and consisted of particles adhering so firmly together, that water would not pass through them; which were hard enough to scratch glass, and which, when scraped with a knife, or rubbed against a fine grindstone, assumed a metallic lustre, and the appearance of iron.

Columbium, by trituration, may be reduced to a dark-brown powder. When heated, it takes fire, and burns feebly to a greyish oxide. It is not acted upon by either nitric, muriatic, or nitro-muriatic acid. Its specific gravity was found by Wollaston to be 5·61. It has been alloyed with iron and tungsten.

CHAPTER XVI.

COPPER.

The name of this abundant, long and well known, metal is said to have been derived from the island of *Cyprus*, where it was first wrought by the Greeks; the alchemists called it *Venus*, the name of the protecting goddess of Cyprus. The ancients made their weapons and agricultural implements of brass or *æs*, an alloy of copper and tin, before that iron was obtained in sufficient quantity to be applied to those purposes. Ample evidence may be obained from classic and Egyptian authorities, that brass was extensively used, and it is said the Egyptians had the art of tempering it; they used it for making bows, and arms of all kinds. The columns of the temple (I. Kings, vii., 13—21), the bath or sea, in the priest's vestibule, the forks used in the sacrifice, and the mirrors were all made of this alloy. Exodus xxxviii, 8, and II. Kings, xxv., 13.

Copper occurs in a state of native purity, in masses, of various forms, varying from an ounce to a ton, and usually possessing a reddish, but sometimes a brownish or blackish colour, *Native copper* is seldom met with in large masses; one, however, has been found in Brazil, weighing 2666 pounds; it occurs in Cornwall, France, Sweden, Hungary, Siberia, and South America.

Copper is also found in combination with sulphur and iron, forming a double sulphuret known as *copper pyrites*, or *yellow copper ore*; this constitutes the whole of the ore raised in Cornwall; it is also found in Devonshire, and Anglesea; in the north of Europe; and in many parts of Asia, Africa, and North and South America. On account of the supply of coal in South Wales, the ores, raised in Cornwall and Devonshire, are sent there to be smelted.

Oxygen is sometimes associated with this metal in nature; often as the red, or *suboxide of copper*, or *ruby copper ore;* and occasionally, as the black oxide.

It also is found combined with sulphur, forming black sulphuret of copper, or *vitreous copper ore*, which contains a small proportion of iron and silex, and is highly prized by the miner; and, with carbon, as *malachite*, and *mountain green*, or blue carbonate of copper, which ore is found in great beauty in the Ural Mountains of Siberia, and in Australia; it is a very valuable ornamental stone. It likewise occurs, associated with acids, phosphurus, and silica.

Copper is met with in several parts of England and Wales; the most extensive and the richest are those of Cornwall, and Devonshire. Cornwall has upwards of eighty copper mines, producing from 100 to 1500 tons annually. Anglesea, where there is a whole hill called Paris-mountain, consisting of copper ore, produces more than 20,000 tons every year.

Besides those of England, copper mines are worked in France, Saxony, Hungary, Germany, Spain, Norway, Sweden, Russia, Siberia, China, Japan, Sumatra, Chili, Cuba, Mexico, in North America, and North Africa. Copper is so very cheap in Sweden, that the houses are covered with it, as is the Coliseum in Regent's Park, London.

A contemporary writer describes the mode of reducing the yellow copper ore, as follows:—"It is first roasted in a reverberatory furnace, by which much of the sulphuret of iron is converted into oxide, while the sulphuret of copper remains unaltered. The product of this operation is then strongly heated with silicious sand; the latter combines with the oxide of iron to a fusible *slag*, and separates from the heavier copper compound. When the iron has, by a re-

petition of these processes, been got rid of, the sulphuret of copper begins to decompose in the flame-furnace, losing its sulphur, and absorbing oxygen; the temperature is then raised sufficiently to reduce the oxide thus produced by the aid of carbonaceous matter. The latter part of the operation consists in thrusting into the melted metal a pole of birch-wood, the object of which is probably to reduce a little remaining oxide by the combustible gas thus generated."

Copper, when pure, possesses a peculiar reddish-brown colour, which hue belongs to no other metal except titanium. It is extrémely nauseous and styptic to the taste, and when rubbed it emits a disagreeable odour; it is very sonorous, elastic, and malleable; the most ductile of all metals, except gold; harder than silver, but softer and more tenacious than iron. Its malleability is such that it is sometimes hammered into thin leaves which are about 1-60,000th part of an inch thick, and sold in little books, as *Dutch gold*, or *Dutch metal*.

Leaf-copper is used for covering toys, decorating theatres and public buildings, and also in the arts for several inferior purposes. As regards tenacity, a wire, ·078 of an inch in diameter, will support a weight of 302·2 lbs. avoirdupois, without breaking. Being very sonorous, copper is employed in the manufacture of trumpets and other musical instruments; and, alloyed with tin, it forms the metal of which bells are made. It melts at 1450 degs. Fahrenheit, and is volatilized by increased heat. It ranks next to gold, silver, and platinum, as a conductor of heat; and it stands first as conductor of electricity. When melted it has a blueish-green colour, resembling melted gold; and, if allowed to cool slowly, it crystallizes in quadrangular pyramids. It is nearly 9 times heavier than water, its specific gravity being 8·958.

It is not acted upon by oxygen, when exposed to dry air, or even pure oxygen, at common temperatures; but, in moist air, it is soon coated with *verdigris*, a mixture of carbonate and oxide. If it be raised to a high temperature, it becomes coated with the red oxide, which after a time is converted into the black oxide. The *red oxide*, or *protoxide*, which was first recognised by Proust, consists of 88·99 copper and 11·11 oxygen, and is usually called *suboxide;* it is often met with in nature as beautiful ruby-red crystals

called *red-copper-ore*. It imparts a deep rich ruby colour to glass, and is used to imitate the ruby and the garnet. It absorbs oxygen with such rapidity, that it can scarcely be dried without becoming black. The *black oxide*, or *per-oxide*, which contains 80 metal and 20 oxygen may easily be obtained by keeping copper filings a sufficient time red-hot. It unites with water, forming a blue coloured matter called *hydrate of copper*. A third oxide has been admitted by Thenard, but very little is known about it.

When equal parts of sulphur and copper are stratified in a crucible, they combine at a red heat, and form *sulphuret of copper*, which is brittle, has a deep blue colour, and consists of 78 copper and 22 sulphur.

Sulphuret of copper may be united with an additional quantity of sulphur, forming a *supersulphuret*, which is brittle, and has a yellow colour and a metallic lustre. It is found in nature, and is known as *copper pyrites*.

Copper combines with most of the metals, forming alloys more numerous and more useful than those of any other metal. *Brass* consists of 70 parts of copper and 30 of zinc; the *orichalcum* of the ancients was the same as our brass. This is one of the most important alloys of copper, being more fusible, and more ductile than that metal, and quite as malleable; from it are manufactured lamps, chandeliers, tubes, pipes, gas-fittings, bedsteads, cornices, frames, telescopes, microscopes, mathematical and other instruments, machinery, wire, pins, and numberless other articles. It may be obtained by filling a pot with layers of powdered calamine (which is an ore of zinc) and charcoal placed alternately with copper; by applying a tolerably strong heat, the zinc is driven in vapour out of the calamine, and penetrates the copper, changing it to brass. *Bronze*, which is remarkable both for the exactness of the impressions which it takes from the mould, and also for its durability, is composed of 100 copper and 8 tin; antimony and zinc are occasionally added. *Gun-metal*, which consists of 100 copper and 12 tin, is a strong and valuable alloy; it possesses more tenacity than copper, and does not become so readily tarnished by air as that metal. *Bell-metal*, the compound of which bells are manufactured, generally consists of 23 tin and 100 copper; the latter is somewhat increased, when the compound is intended for large bells. Brass, spelter,

lead, and occasionally silver, are sometimes added to improve the sonorousness of the alloy. *Speculum metal* contains 60 copper to about 100 tin, with a little arsenic, silver, and zinc; it is very hard, and admits of a fine polish. *German silver*, or *argentane*, which is nearly as white as silver, and takes a fine polish for spoons and forks, consists of 50 copper, 25 nickel, and 25 zinc. Chinese *hackfong* is composed of 40·4 copper, 31·6 nickel, 25·4 zinc, and 2·6 iron. *Mannheim gold* is a peculiar alloy, containing 75 parts of copper and 25 of zinc. *Tutenag* is said to be an alloy of copper, zinc, and a little iron. *Similor* contains rather more copper than exists in brass. *Ormolu* is a compound of 48 copper and 52 zinc. Copper is alloyed with arsenic, to which a little tin is afterwards added, for the formation of *tombac*, or *white copper*. *Pinchbeck*, *Prince's metal*, or *Prince Rupert's metal*, consists of copper and zinc. Copper combined with sulphuric acid forms *Roman vitriol*, which is much used by dyers and in the arts.

No other metal, except iron, occupies so prominent a position, with reference to its extreme usefulness to mankind, as copper; indeed, it would require a large volume to enter into all the uses of this valuable metal.

Copper, in a metallic state, produces no action in the human system; but, unlike iron, solutions of which are a valuable medicine, those of copper are extremely poisonous.

It is used in manufacturing kettles and saucepans*; candlesticks are often made of brass, or prince's metal; pins are generally made of brass, and coated with tin. Sheets of copper are sometimes used to cover buildings; and a large quantity is consumed in sheathing ships, that is, in covering all that part under water, to protect the timber from the depredations of a peculiar kind of shell fish, and also to make the ship sail faster. It forms part of the metallic currency of the realm; 1 lb. of copper is coined into 24 penny pieces.

* All copper utensils employed in preparing food should be kept scrupulously clean and bright, for a portion of the metal becomes dissolved, when acted upon by acids, fats, and fat oils, for some length of time. And those articles, which are lined with tin, should be carefully inspected before being used, as the tin frequently gets worn off, and the copper, being exposed, will impart more or less of its poisonous qualities to the contents of the vessels.

CHAPTER XVII.

DIDYM, OR DIDYMIUM.

DIDYMIUM is a metal occuring in a rare mineral called cerite. It was discovered by Mosander in the year 1840, and was so called from its being, as it were, the *twin*-brother of lanthanium, with which it was previously found associated in the same substance.

Crude oxide of cerium owes that brown colour, which it occasionally possesses, to the presence of oxide of Didymium.

According to Fownes, the atomic weight of this metal is 48.

CHAPTER XVIII.

ERBIUM.

THIS very rare metal, which resembles aluminium in its appearance, is found in orthite. It was first obtained by Professor Mosander, in 1840, from ordinary yttria, which mineral he declared to be a mixture of the oxides of erbium, terbium, and yttrium.

Very little, indeed, is known concerning the properties of this scarce metal.

CHAPTER XIX.

GLUCINIUM, OR BERYLLIUM.

THIS metal received its name *Glucinium*, from a Greek word signifying "sweet," in consequence of the sweet taste which some of its compounds possess.

It was discovered by Wöhler in the year 1828, in a very rare earth *glucine*, or *glucina*, which occurs only in those valuable gems, the emerald, beryl, the euclase, and the scarce mineral gadolonite; and which was first obtained by Vauquelin in 1798. Wöhler procured this metal by decomposing the chloride of glucinium.

Glucinium, or beryllium, is a fine powder of a dark-gray colour, which requires to be burnished to produce its metallic lustre. It is malleable, fuses at a point rather below that at which silver melts, and has a specific gravity of 2·1. It undergoes no change when in contact with either air or water at common temperatures; but when heated to redness, it burns brilliantly, and, combining with oxygen, is converted into the oxide glucina.

Glucina, glucine, or *berylla*, the only known oxide of this metal, is a soft, white powder, infusible (except by the oxy-hydrogen blow-pipe), insoluble in water, but forming a paste with that liquid, and consisting of 100 parts metal and 44·44 oxygen. This metal is called by some, *glucinum*.

CHAPTER XX.

GOLD.

If we were to visit some large ship on the eve of its sailing for Melbourne, we should, doubtless, not very quickly forget the curious and almost painfully interesting scene presented by the multitude of emigrants thronging its decks and the adjoining quay. In all probability four-fifths of these persons would be starting to seek their fortunes at the gold-diggings; for, to use the words of a modern poetess:—

"How many leave a happy home,
And 'mid the world's temptations roam,
Australia's gold to see,
And help the others to explore
The wonders of that distant shore,
In ecstasies of glee!"—E. Gurson.

But how few of these emigrants would probably know what gold really is! Yes, there would be but few who could

distinguish it from yellow mica, or from iron pyrites; and only a very small proportion of them would know even the simplest chemical test for this precious metal. How highly necessary is it that every gold-seeker should have a good knowledge of the properties, &c., of this metal, else he may be as unfortunate as the man, who (according to Professor Forbes) having found a piece of quartz-crystal in California and fancied it was a diamond, refused £260 for it there; he brought it to England, but it was only to learn that it was worthless.

This metal, on account of its unchangeableness on exposure to air or water, its beautiful colour, its fine metallic lustre, its great specific gravity, and its being found usually in the native metallic state, has been regarded as the "king of metals" from the remotest antiquity. We find it first noticed in connection with one of the rivers of Eden:—"The name of the first is Pison; that is it which compasseth the whole land of Havilah, where there is gold; and the gold of that land is good." It was made into ornaments in very early times, and was largely employed in the construction of the tabernacle in the wilderness, and, subsequently, of the temple. Ophir, Sheba, Uphaz, and Parvaim, mentioned in the Old Testament as gold districts, cannot now be identified. The Jews obtained their gold chiefly from Sheba and Ophir, both of which were in Arabia, I. Kings, ix., 28, Psalm xlv., 9. Ancient writers affirm that it was formerly found in considerable quantities, but no gold is met with there now. Beaten or perhaps alloyed gold, is mentioned, I. Kings, x., 16—17. We also read that gold and silver were sometimes purified by fire, Prov. xvii., 3; lead, antimony, salt, tin, and brass, being employed for this purpose.

Gold is considered as the most widely-diffused of the metals; it generally occurs in a metallic state associated with a little silver, or copper, or occasionally tellurium; and is frequently discovered in the sand or soil of rivers, the precious metal having been washed down from the mountains in the form of gold-dust. Some of the iron pyrites, and galena also, contain a sufficient quantity of gold to make them valuable as ores of that metal. When gold occurs alloyed with a considerable quantity of silver, it is known as *electrum*. Klaproth, having analyzed this native alloy,

found it to consist of 64 parts of gold and 36 parts of silver.

When it is found as fine dust mixed with the sand of the rivers, the mode of separating it is as follows:—Some of the river-soil is first washed in a shallow pan; the gold, being much heavier than the sand, soon sinks to the bottom; the water clouded with sand is then gently poured off. This being repeated several times is often sufficient to answer the purpose; but mercury is sometimes employed to complete the process; this, speedily uniting with the gold, separates it from the rock or sand. The metal thus obtained is not always pure, being generally alloyed with silver or copper.

When in combination with silver, the gold is first melted with three times its weight of silver; this alloy is then boiled in strong nitric acid two or three times, changing the acid each time. Nitric acid possesses the property of dissolving silver, but does not act upon gold; the acid containing the silver may now be removed, leaving the gold pure.

The separation of gold from copper is performed by a process called *cupellation;* that is, the gold is melted with some lead in a porous cup called a *cupel*, through which the lead and copper pass in the state of oxides, leaving the gold behind.

Native gold is found in scales, threads, grains, or small crystals, which when of a certain magnitude are called *nuggets*, and have occasionally been met with of magnificent dimensions. There is a mass of gold in the Museum of the Mining Engineers, at St. Petersburgh, weighing 100 pounds, Troy weight. In 1821, a mass, 8½ inches long, by 4½ inches broad, and about an inch thick, was found in the United States, which weighed 28 pounds. A larger specimen was found in some alluvial deposits in the island of Hayti, in the year 1502; it weighed 32 pounds. California has yielded masses of very considerable magnitude; one, discovered on the Asiatic side of the southern portion of the Urals, weighed 96½ pounds Troy; it was valued at £4,000. The largest mass yet found was obtained from Australia,—a nugget weighing 2,217 oz. 18 dwts., and about 22 carats fine.

California, Peru, Brazil, Mexico, Chili, North and South Carolina, Transylvania, the Ural and Altai Mountains,

British Columbia; Siberia, Tibet Proper, Japan, Burmah; Hungary, Norway, Sweden, Ireland; and Guinea (from which the name of our ancestors' largest gold coin was derived) and Zanguebar, in Africa, are the principal places which supply this precious metal. The gold of Asia, particularly the East Indies, is the finest; but that of South America is the most plentiful. Europe furnishes comparatively little, its richest mines being those of Hungary; it has been found in the sands of the Rhone, the Rhine, and the Danube; and no inconsiderable quantities have from time to time been collected in the stream tin-works of Cornwall, in Wicklow in Ireland, and in the lead-hills of Scotland.

In some cases, the operations, though exceedingly promising at first in their results, are abandoned in consequence of the great flow of water from springs that are opened during the downward course of the boring machinery.

> "So wealthy mines, that ages long before
> Fed the large realms around with *Golden ore*,
> When choked by sinking banks, no more appear,
> And shepherds only say, 'The mines were here.'"

The gold district in Australia is supposed to be about 1000 miles in length, by 400 in breadth; and only a small portion of it has as yet been explored. The most important gold-fields in New South Wales, are in the valley of the Macquerie River.

Gold has a fine yellow colour, which varies in intensity, and a considerable metallic lustre, and is destitute of either taste or smell; it does not become tarnished when in contact with either air or water, and it resists the solvent influences of all the ordinary acids. *Aqua regia*, a mixture of nitric and hydro-chloric acids, is usually employed to dissolve this metal; a solution is formed, which gives to animal matters a deep purple colour, and corrodes them. The precipitate formed by ammonia from this solution has a yellow colour, and it possesses the property of detonating with very considerable noise when slowly heated. It is called *fulminating gold*; it fulminates violently when heated to between 300 and 400 degs. Fahrenheit, or when smartly struck with a hammer, or when triturated in a mortar. Water is formed,

and azotic gas emitted. It is composed of 5 parts of yellow oxide of gold and 1 part of ammonia.

If a plate of tin be immersed in a solution of gold, a purple powder will be obtained, known as the *purple powder of Cassius*, which is used to paint in enamel.

Gold is almost as soft as lead. It requires a heat of 2016 degs. Fahrenheit to fuse it, which does not happen till after ignition; when melted, it assumes a bluish-green colour; this colour is also exhibited by light transmitted through gold-leaf. It may be kept in the hottest furnace for several weeks without sustaining any loss, or undergoing any change, except remaining in a melted state. When carefully cooled after fusion, it crystallizes in four-sided pyramids.

The specific gravity of gold is 19·361, that of water being 1·000. Its malleability is such that a single grain, which would scarce be bigger than a pin's head, when beaten out to its greatest extent, will cover a space of 56½ square inches. *Leaf-gold* is obtained by beating, with heavy hammers, a plate of gold, placed between folds of membrane, till it is spread out to an almost incredible degree of thinness; these leaves are only about 1-282,000th part of an inch in thickness, and will float like feathers in the air. But the *gold-leaf* with which silver wire is covered has only one-twelfth of that thickness. An ounce of this metal would be sufficient to cover a silver wire 1300 miles long. It is so malleable, that the gold-beaters find it necessary to add 3 grains of copper to one ounce of gold, which otherwise would pass *round* the irregularities of the newest skins, instead of *over* them; and in using the old skins, which are not so perfectly smooth, they frequently have occasion to add 12 grains.

As regards ductility, one grain of gold may be drawn into wire 500 feet long; this is performed by drawing a cylindrical rod of the pure metal through a series of holes, which gradually decrease in size, punched in a steel plate. Its tenacity is such that a wire, only one-tenth of an inch in diameter, will support a weight of 500 pounds, without breaking.

Gold combines with oxygen in two proportions. The *protoxide*, or *purple oxide*, is formed when violent electrical explosions are passed through gold-leaf; it consists of 100

gold and 6 oxygen. The *peroxide*, which is of a yellow colour, and is composed of 100 gold and 20 oxygen, may be obtained by dissolving gold in nitro-muriatic acid, and precipitating the metal, by means of a solution of either potash or lime; it falls as a *yellow oxide.*

Gold is applied to many important purposes; but from its softness, and consequent liability to be worn down, it is mostly employed in an alloyed, and not in a pure, state.

The purity or fineness of gold is generally announced by goldsmiths in the following manner. Pure gold is divided into 24 parts, called *carats;* gold of 24 carats, therefore, means *pure* gold. Gold of 23 carats, means that it consists of 23 parts of gold and 1 part of some other metal. Gold of 22 carats is composed of 22 parts of gold and 2 parts of another metal. The number of carats mentioned, indicates the pure gold, and what that number wants of 24, specifies the quantity of alloy. Articles of jewellery, when 18 or more (not less) carats fine, are stamped in figures at Goldsmith's Hall. *Sterling gold,* as it is termed, is gold of 22 carats. Compounds exist, under the name of *jeweller's gold,* of every possible degree of deterioration. *Standard gold* has two extremes; it may be composed of 22 gold + 2 copper, or it may consist of 18 gold + 6 copper; *i.e.,* it may be either sterling or jeweller's gold.

The gold coin of the realm contains 22 parts of fine gold and 2 parts of copper; in the time of Edward I. it was composed of 22 parts or carats of fine gold, 1 of silver, and 1 of copper. The mint price of gold, that is, the standard value at which it issues it, is £3 17s. 10½d. per oz.; and 20 lbs. Troy are coined into 934½ sovereigns, or, in other words, 1 pound Troy produces 46 and 29-40ths sovereigns (formerly 44½ guineas), each sovereign weighing 123·274 grains.

The first mention we have of gold being employed for money is in David's age (I. Chron., xxi., 25).

Besides being employed for current coin, this metal is used for jewellery, and for plate. Gold is also spread over other metals, in the process of gilding, to preserve them from tarnishing or rusting. The *purple oxide* is employed in staining glass, and for ornamenting porcelain.

CHAPTER XXI.

ILMENIUM.

ILMENIUM is a metal said to be found with tantalium, which it resembles; its existence, however, is denied by several. It no doubt received its name from Lake *Ilmen*, near Minsk, in Russia.

CHAPTER XXII.

INDIUM.

THIS newly-recognised metal was discovered in 1863, by Drs. Reich and Richter, of Freiberg, in Saxony, in the Freiberg zinc blende, by means of spectrum-analysis; it was termed *Indium*, from the two splendid indigo-blue lines which characterize its spectrum. In its chemical relations it resembles zinc, with which it occurs associated in nature; it may be reduced before the blow-pipe to a soft, malleable, and ductile bead, which will mark upon paper, not so darkly as lead, but somewhat like tin; the metallic bead will dissolve in hydro-chloric acid with the evolution of hydrogen. The *oxide of indium* may be formed as a yellow fusible incrustation by heating the metal before the blow-pipe on charcoal. Indium differs from zinc in the insolubility of the hydrated oxide in excess of both ammonia and caustic potash. This new element may be separated from all the known metals by precipitating its sulphide in alkaline solution, and by throwing down the hydrated oxide first with ammonia, and then with caustic potash; and, lastly, by precipitating the iron with dilute solution of bicarbonate of sodium. By this process, we obtain the hydrated oxide of indium in solution in the pure state. In all the pure compounds of this metal, indium may be readily detected by the deep purple tint which these impart to flame.

Indium has hitherto been found only in the very smallest quantity; hence its atomic weight and the composition of its salts have not yet been determined. Up to the present time it has only been detected in the zinc blende of Freiberg; but it will, doubtless, soon be discovered in larger quantities, and its compounds more closely studied.

CHAPTER XXIII.

IRIDIUM.

Iridium, so named from *iris*, the rainbow, on account of the variety of colours exhibited by a solution of oxide of barium and potassa in hydro-chloric acid, was discovered by Professor Smithson Tennant, in the year 1803, and according to the Annals de Chimie, by a foreign chemist named Descotils.

This peculiar metal was found alloyed with osmium in the black powder which usually remains behind undigested when crude platinum is dissolved in aqua regia. This black powder is to be mixed with an equal weight of potash in a silver crucible, and kept in a red heat for some time. From this, water procures an orange-coloured solution; the remaining undigested powder is to be dissolved in hydro-chloric acid, and afterwards again subjected to the action of potash as before. This must be repeated till all is dissolved. We then have an orange-coloured alkaline solution, holding the oxide of osmium, and a deep-red acid solution of oxide of iridium. If we evaporate this latter solution to dryness, we may obtain octahedral crystals of hydro-chlorate of iridium. From a solution of these crystals, a plate of any metal, save gold and platinum, will precipitate the iridium in the form of a black metallic powder. This powder, after having been purified by a strong heat (but it can scarcely be said to have been fused), is rather whiter than platinum.

Vauquelin states that it is probable that after a perfect fusion, iridium may be slightly ductile. Its specific gravity is 18·68; it is brittle, soluble in muriatic acid, but neither

the nitric nor sulphuric acid has any action upon it; it may be alloyed with several of the other metals, the hardness of which it greatly increases. There are two oxides of this metal; the *protoxide* which has a *deep blue* colour, the colour of the *peroxide* is *dark red*.

Iridium formed alloys with all the metals tried, except arsenic; it does not alter the colour of gold, and cannot be separated from gold and silver by cupellation. It forms with copper a very malleable alloy.

CHAPTER XXIV.

IRON.

Iron, although the most useful, and in England the most abundant of all the metals, was not known to the inhabitants of the earth, so early as gold, silver, or copper, which, as they frequently occur native, no doubt attracted attention sooner than this metal. It is believed that the Israelites possessed the knowledge of the reduction of the ores of iron in the time of Moses, but it is not known how or whence they obtained it. The art of working it was communicated to the Greeks by the Phrygians, and from them it gradually become circulated through the other inhabitants of Europe. In Deut. viii., 9, we read that it was largely found in Syria; and on referring to Deut. xxvii., 5, and Numb. xxxv., 16, we find that instruments and tools were made of it.

This is the most universally diffused metal throughout nature, and is met with in combination in every part of the mineral, vegetable, and animal kingdoms. It is plentiful in England, Wales, and Scotland; the principal home sites of production are Gloucestershire, Staffordshire, Derbyshire, Yorkshire, and Lancashire, in England; South Wales; and Lanarkshire and Stirlingshire, in Scotland. And close to the iron mines, generally speaking, there is an abundant supply of coal, with which to work the iron; "this," says a worthy author, "with many other things with which we are surrounded, tells us of God's merciful goodness; and

proves that He made and furnished the world as a habitation for Man, destined to be its occupant."

"Acquaint thyself with God, if thou would'st taste
His works. Admitted once to his embrace,
Thou shalt perceive that thou wert blind before;
Thine eye shall be instructed; and thine heart
Made pure shall relish, with divine delight,
Till then unfelt, what hands divine have wrought."—COWPER.

Iron is also found in France, Spain, Sweden, Belgium, Austria, Saxony, Russia, and the United States—in all of which countries the supply will suffice, even at the present enormous demand, for ages to come.

"A world of wealth is sleeping
In subterraneous night;
What the mountains have in keeping
Shall soon be brought to light;
And wealth and strength and beauty
Shall be spread o'er all the land,
When awakens to its duty
The mighty human hand.

"To fell the forest soaring,
To cultivate the plain,
To chase the lion roaring,
To navigate the main,
The mind of man is poring
In the chasms under ground,
Their secret hoards exploring,
Till the *iron-ore* is found!

"But not with pike or sabre
Will we show the *iron's* might;
It shall shine in quiet labour,
And not in cruel fight;
It shall thunder o'er the nation,
In the rapid, streaming train,
And carry to starvation
The loads of precious grain.

"In wheels and axles spinning,
It shall work for man and child,
Or in the ploughshare, winning
Rich gardens from the wild;
It shall work man's liberation,
When the wise directing mind
Shall plan earth's reformation
With measures true and kind.

"No! not for the bloody battle
Will we whet the *iron* blade;
No! it shall rather rattle
On the oak i' the forest-glade,
And cleave the stubborn granite,
And hew the marble white,
Till it make our beauteous planet
With toil's creation bright!"—JOSEPH GOSTICK.

It likewise occurs in leaves, fruits, stalks, stems, and flowers; in the soil upon which we tread, and in several minerals, in the flesh and blood of man and animals; and even in milk and water. Iron is likewise found, in a malleable state, in meteoric stones, in combination with nickel and other metals.

The *clay iron stone* is the most important and plentiful of the ores of this metal. It consists of the carbonate of the protoxide of iron associated with clay, the carbonates of lime, magnesia, manganese, as well as coaly matter. It is supposed to contain about 30 per cent. of metallic iron.

Magnetic iron ore, or the *black oxide*, occurs in several parts of the world in great abundance; it may readily be reduced to the metallic state by merely heating it with coke or charcoal. The iron which it yields affords a very fine quality of steel.

The *red oxide of iron*, termed by mineralogists *haematite*, in allusion to the blood-red colour, is quite as reducible, and as valuable as the last mentioned ore.

The alchemists gave to iron the name and symbol of *Mars*, the god of war.

The bluish-white colour of iron is familiar to almost everybody. When pure, this metal is soft and ductile; in a state of solution it has a sweet and styptic taste; and when rubbed it emits a peculiar odour. It has a strong metallic lustre, which is capable of being heightened by polishing, It readily gives fire by collision with flint and silicious stones, and is the most elastic of all metals. This and nickel are the only two metals capable of permanent magnetism; but pure iron, although it may be rendered magnetic by various processes, does not long retain this property; by the addition of oxygen, sulphur, and carbon, however, it may be rendered permanently magnetic.

"The advantages," says Samuel Parkes, "which we derive from the magnetic property of iron are incalculable. To

this astonishing property we are indebted for an instrument —the *mariner's compass*—by which man is enabled to traverse the ocean, to open a friendly or commercial intercourse with every quarter of the world, and to steer his course towards any particular country, with the utmost accuracy and certainty."

> "Tall navies *hence* their doubtful way explore,
> And ev'ry product waft from ev'ry shore;
> Hence meagre want expell'd, and sanguine strife,
> For the mild charms of cultivated life."—BLACKLOCK.

Iron, when it is cold, is malleable, and its malleability is increased with the temperature, but in this respect it is inferior to either gold or silver, although it is superior to them as regards ductility. The surface of iron, when it is violently heated, becomes soft, and if two pieces in this state be hammered together, a perfect union is effected; this may done without melting either of the pieces. Iron and platinum (and some say sodium) are the only metals possessing this singular property, which is known to artificers by the term *welding*. Its tenacity is very great: an iron wire, only 0·078 inch in diameter will bear a weight of 549·25 lb., without breaking, and a wire of tempered steel of the same size will (according to Dr. Black) carry nearly 900 lb. M'Kenzie asserts that the fusing point of iron is about 158 degs. of Wedgewood, or 3480 degs. of Fahrenheit. It is not a dense metal, its specific gravity being only 7·77.

When iron is left exposed to the air, especially in a moist place, a red or yellow powder is soon formed, which is commonly called *rust*, and which is nothing else than an oxide of iron generally combined with carbonic acid. If vapour of water be passed through red hot iron, the iron becomes rapidly oxidized, and much hydrogen gas is obtained. This metal at a red heat decomposes water with great rapidity.

Chemists recognize two oxides of iron, the *black* and the *red;* the former is known as the *Martial Æthiops* of the Materia Medica, and may be obtained by plunging an iron wire, having a small piece of lighted cotton at its extremity, into a jar of oxygen, when it will burn with great brilliancy, and being converted into the black oxide, will fall to the

bottom of the jar in melted drops. It may also be obtained by keeping iron filings a sufficient time in water, by making steam pass through iron filings at a red heat, and, by dissolving the metal in diluted sulphuric acid, and dropping potash into the solution. It is a black powder, insoluble in water, attracted by the magnet, and possesses great metallic lustre. It is composed of 78·5 iron and 21·5 oxygen.

The *red oxide* or *peroxide* is formed by keeping iron filings red hot in an open vessel, and constantly stirring them till a deep red powder is produced. It is insoluble in water, and forms the base of many of the common red paints; clay and bricks owe their yellow and red colours to it; it consists of 69 iron and 31 oxygen. It was formerly designated *Saffron of Mars.*

Plumbago, or *Graphite*, the *carburet of iron*, commonly called *black lead*, is a soft substance found native, possessing a dark blue colour, a granular texture, and the metallic lustre. It does not burn with a flame but gradually wastes away when red hot. If it be cast into melted nitre a very splendid combustion follows. According to Berthollet 100 parts of plumbago contains 90 parts of charcoal and 10 of iron. The best is found at Keswick, in Cumberland, and is used in making pencils.

Pure iron, *soft iron*, or *malleable iron*, is a metal of a silver-grey colour, fusible at a temperature of 3330 degrees, being far less fusible than either cast or wrought iron. It is soft and ductile; its solutions have a sweet and styptic taste; when subject to friction it emits a peculiar odour; it is attracted by the magnet, has the property of becoming itself magnetic; it readily gives fire by collision with flint and silicious stones; it is the most elastic of all metals. Its specific gravity is 7·84.

The ore of iron is fused in large furnaces, and made to flow into moulds of sand; it is then termed *cast iron*, of which cannon, pipes, stoves, and other articles are made. In this state it may be either *white*, *grey* (or mottled), or *black*, according as it contains a *larger* proportion of *carbon*, an *equal* amount of *carbon* and *oxygen*, or a *larger* amount of *oxygen*. Besides carbon and oxygen, however, some silicon, derived from the silica of the clay, as well as manganese, and sometimes calcium, magnesium, and aluminium,

are present in small quantities in *cast* iron. *Cast iron*, or *pig iron*, is the name of the metal when first extracted from its ores; the ores generally used are a mixture of the oxide of iron and clay. They are reduced to small pieces, mixed with charcoal and lime, and exposed to a violent heat; the charcoal separates the oxygen, while the lime combining with the clay, forms a liquid through which the melted iron falls, and is collected at the bottom of the furnace; it is then let out and cast into moulds. It possesses a highly crystalline structure, and is more brittle and fusible than malleable iron.

After fusion cast iron expands in becoming solid, and, therefore, is capable of taking very sharp impressions from a mould. Cast iron fuses at a temperature of 2786 degrees, and its specific gravity varies from 7·2 to 7·6.

Cast iron is converted into *wrought* or *soft* iron by keeping it in a state of fusion for a length of time in a bed of charcoal and ashes, and the *scoriæ* or *black oxide* of iron, and then forging it repeatedly till it becomes compact and malleable.

Hot-short iron is an inferior quality of wrought iron; it is a fusible metal, possessing ductility when cold, but is so brittle when heated, that it will not bear the stroke of the hammer. *Cold-short iron* is another inferior kind of wrought iron, it is very malleable and ductile while hot, but the utensils made of it are as brittle as cast iron, when cold.

Steel is made of wrought iron, heated between charcoal and suddenly cooled, whereby the metal resumes a certain amount of the carbon, and acquires a closer grain, and a capacity of receiving different degrees of hardness; and is less apt to rust than common iron. It is so hard as to be quite immalleable while cold; it is brittle, resists the file, strikes fire with flint, and is capable of being converted into a magnet. Its specific gravity varies from 7·78 to 7·84. The quantity of carbon existing in steel (according to Vauquelin's analysis) amounted to 1-140th part of the whole. The most important property of steel is that it acquires great hardness and elasticity if it be raised to a high temperature. It is rapidly cooled by being plunged into oil or cold water, the metal at the same time becoming brittle; if the metal be cooled slowly from a red heat, it becomes soft, like pure iron, having lost its brittleness and elasticity, and will not readily take or keep a sharp edge.

An eminent writer tells us that "the *tempering* of steel consists in reducing its excessive hardness to a moderate degree, by a gentle heating, which also restores its toughness and elasticity. In the year 1789, Mr. Hartley obtained a patent for a mode of tempering steel, by immersion in oil, heated to a regulated temperature, measured by a thermometer. This was certainly a great improvement, both in point of precision and despatch, on the common method of heating the instrument over a flame, till a certain colour produced by a film of oxide appears on its surface.

At 430 degs. F. a very faint yellow, for lancets.
„ 450 „ „ a pale straw colour, for razors and surgeons' instruments.
„ 470 „ „ a full yellow, for penknives.
„ 490 „ „ a brown colour, for scissors, and chisels for cutting old iron.
„ 510 „ „ a brown, with purple spots, for axes, and plane irons.
„ 530 „ „ a purple, for table knives, and large shears.
„ 550 „ „ a bright blue, for swords; and watch and bell springs.
„ 560 „ „ a full blue, for small fine saws, daggers, &c.
„ 600 „ „ a dark blue, verging on black, is the softest of all the gradations, when the metal becomes fit only for hand and pit saws, which must be soft, that their teeth may bear sharpening by the file, and setting by the hammer, or pliers."

Iron unites with gold, silver, tin, and platinum. When raised to a white heat, and thrown into mercury, it becomes coated with that metal.

We learn, from that admirable work, the "Popular Science Review" for April, 1864, that, in concluding a memoir, presented to the Royal Academy, on the action of manganese in the smelting of iron, "M. H. Caron observes that, in mixing with their ordinary ores those which contain large quantities of manganese, with a view to the improvement of the products, iron-masters may with advantage gradually increase the proportion of flux, without rendering their slag less liquid to any injurious extent. He recommends the employment of sea-salt, or chloride of calcium, when the flux becomes difficult to manage. He also suggests the use

of fluor spar or cryolite, but states his objection to these substances, on the ground of their containing considerable quantities of phosphoric acid, which is exceedingly destructive of cast-iron."

This metal is certainly the most useful substance in the world; for there is not any article upon which we can gaze, which is not indebted to iron, in one way or another, for its form; it adapts itself to all our wants, and desires, and even our fancies; it is equally serviceable to the arts and to the sciences, to the agriculturist, and the warrior. Iron is frequently, from improper diet, and other causes, deficient in the blood, hence the use of its salts as a medicine; this is the only metal partial to the human frame.

CHAPTER XXV.

LANTHANIUM.

The oxide of this metal is found in combination with the oxides of cerium and didymium in the Swedish mineral called *cerite*.

Fownes states that the oxide of Lanthanium, as pure as it has been obtained forms a very pale salmon colour powder, unchanged by ignition in open or close vessels. In contact with water, it gives a snow-white bulky hydrate, which has an alkaline reaction, and decomposes ammoniacal salts by boiling. It salts are crystallizable, colourless, sweet and astringent, and are precipitated by sulphate of potassa.

It is also called *lanthanum*, *lantanum*, and *lantanium* (from the Greek, *lanthano*, to lie hid).

CHAPTER XXVI.

LEAD.

History furnishes us with no record of the first discovery of this metal; it must have been known from the very earliest ages as we find it frequently spoken of by Moses.

The ancient Greeks and Romans were well acquainted with it; for it was applied by them to a variety of purposes. They fastened sheets of lead with bronze nails to the bottom of their ships, just as our ships are sheathed with copper; they also used leaden pipes for the purpose of conveying water. Lead during the first year of the Christian era, was 24 times as dear as it is now in Europe, whereas tin was only about 8 times its present value. Lead, in the state of *ceruse*, was in great request among the Roman ladies, by whom it was used as a cosmetic. The Alchemists identified it with *Saturn*, under whose name they spoke of it, and by whose symbol they represented it.

Lead is a coarse, heavy metal, possessing a bluish-white colour; it is very brilliant when first cut with a knife, or when newly melted, but by being exposed to the air it soon becomes tarnished; but the film of oxide produced protects it from further change. It will mark writing-paper, though not so darkly as plumbago; it is tasteless; when rubbed violently it emits a peculiar smell, and leaves a stain upon the fingers, or paper, of a dark blue colour. It is highly malleable, but is neither very ductile nor tenacious; a lead wire 0·078 inch in diameter will support only 27·7 lb. without breaking. It is unelastic, scarcely sonorous, and so soft that it may be scratched with the nail, and easily reduced to very thin plates by the hammer.

Lead is brittle at the time of congelation, and in this state it may be broken to pieces with a hammer, and the crystallization of its internal parts will exhibit an arrangement in parallel lines. Its specific gravity, which is not increased by hammering, is 11·445. It melts at 612 degs. Fahrenheit, and when slowly cooled it crystallizes in four-sides pyramids; if it be exposed to a higher temperature, it boils and evaporates; at the heat of burning hydrogen, urged by oxygen, it burns with a bluish flame. If it be exposed to air while in a state of fusion, and kept continually stirred, it absorbs oxygen, and is at length totally converted into an oxide.

There are three oxides of lead. The *protoxide* consists of 100 parts of metal, and 7·692 of oxygen; it may be obtained by the following process:—When lead is melted in an iron ladle, a scum quickly appears upon its surface; if this be taken off, another will immediately succeed; and in this

way the whole lead may be converted into a pellicle, which is the protoxide. By longer exposure to heat in an open vessel, more oxygen is absorbed, and the oxide which assumes a yellow colour, is termed *massicot*, or if it be semi-vitrified it is called *litharge*. When litharge is fused by a stronger heat into a compact mass, it is known by the name of *glass of lead*. *Acetate of lead*, often called *sugar of lead*, on account of its being a crystalline mass, somewhat resembling loaf sugar, and having a sweet taste, may be obtained by dissolving litharge in acetic acid. The best counter-poison, for a dangerous dose of sugar of lead, is a solution of Epsom or Glauber salt liberally swallowed; either of which medicines immediately converts the poisonous acetate of lead into the inert and innoxious sulphate. Sugar neutralizes the poisonous influences of acetate of lead, and therefore it may be considered as an excellent antidote to it.

Protoxide of lead, when it is pure, has a delicate straw-yellow colour, is very heavy, without taste or smell, insoluble in water, but soluble in potash or acids, and has a specific gravity of 9·421. *White lead*, or *ceruse*, so much used as a pigment, is a carbonate of the oxide of lead, or, in other words, a compound containing the yellow oxide of lead and carbonic acid. It may be prepared by exposing thin plates of lead to the vapour of hot vinegar, or acetic acid.

The *deutoxide* of lead contains 100 parts metal with half-as-much more oxygen as the protoxide, or 11·538; it has a bright red colour, and is known in the arts by the name of *minium*, or *red lead*. It may be obtained by exposing, for forty-eight hours, finely powdered massicot, in such a furnace, that the flame may constantly play upon the powder, which is kept continually stirred so as to expose fresh particles. When made into paint with linseed-oil and turpentine, it constitutes what the house painter terms *priming*, it being usually the *first* paint that is applied to new wood or plaster work; it dries very hard, effectually fills up pores, and preserves the wood. The poisonous effect of lead may be seen in the specific disease which afflicts house painters, and has the name of *Colica Pictorum*. Minium is a tasteless powder, of great specific gravity; by exposure to a red heat, it loses a portion of its oxygen, and melts into a dark brown glass.

The *peroxide* of lead is a puce coloured powder, which may be obtained by dispersing the yellow oxide through a mass of water, and then passing a current of chlorine through the liquid; there results a soluble hydrochlorate of lead which may be separated by washing, and the peroxide of lead is an insoluble powder. It consists of 100 lead + 15·4 oxygen.

Galena, or *lead glancea*, a rich native *sulphuret of lead*, is the only ore from which the metal is extracted; the smelting of galena is very simple. The ore which is very abundant, after being brought from the mine is *hand-dressed*, by which as much as possible of any impurity is expelled; what is left is then washed, put into a reverberatory furnace, and the sulphur expelled; the fire is then made brisk, by which the metal is fused, and sinks to the bottom, and is let out into moulds, which give it the form of blocks or slabs, called *sows* and *pigs*.

Lead is also found in a great variety of combinations, but they are almost all objects of interest merely to the mineralogist, except galena, from which the lead of commerce is derived.

Galena occurs in veins in great abundance, in the mountain limestone districts, and generally contains some proportion of silver, which is frequently so great as to pay the expense of separating it. The proportion ranges, in the North of England from 2 to 24 ounces of silver per ton of ore; but in Cornwall as many as 100 ounces per ton have been obtained, and even 140 at the Beer Alston mines in Devonshire.

Besides being found in Cornwall and Devonshire, lead occurs in Somersetshire, Derbyshire, Yorkshire, Northumberland, and Durham; in Wales, Scotland, Ireland, France, Spain, Austria, and Germany; but the lead mines near Missouri, near the Mississippi, are reckoned the richest in the world, where the ore occurs in great abundance, a foot or two from the surface, in detached masses, weighing from 1 to 1,800 pounds. A great mineralogist, in writing upon lead, states that through a district extending nearly 90 miles from east to west by upwards of 50 miles from north to south, embracing parts of Wisconsin, Iowa, Illinois, and Missouri, there is scarcely a square mile without indications of the ore.

The mines of Great Britain furnish upwards of 30,000 tons of smelted lead; in other words, one half of the whole world's consumption.

The uses of lead are very extensive. Being malleable and flexible, and readily united by solder, it is employed in making roofs of houses, gutters, pipes, and spouts to carry off rain water; and is likewise used for tubes in pumps, and for pipes to convey water underground; for lining reservoirs, and conducting gas. But the surface of lead is readily acted upon by soft water, containing oxygen and carbonic acid. Now lead, although a slow, is yet a most fearful poison, and its salts have a sweet taste, so that in a dilute state it gives no unpleasant warning of its presence. Very fortunately, however, most waters contain gypsum, the sulphuric acid of which combines with the oxide of lead, and forms with it an insoluble salt. Spring water may be kept in cisterns of lead, if the covers be made of wood; else, the pure water which evaporates and accumulates in drops upon the lid, will probably dissolve it in small quantities, and thereby impart the poisonous properties to the water.

Sheet lead is made as follows:—A large furnace is provided into which pig-lead is thrown, and heat applied; when the lead is fused the valve or cock is opened in the side of the furnace, and the glistening liquid metal runs forth, and falls upon a large table, covered over with an even surface of fine sand, and having a ledge of an equal height above the sand all round it; as soon as the liquid metal is poured on the sand, two men, holding each end of a stiff wooden rule, called a *strike*, draw it along the table, resting it on each side of the ledge; the metal in a state of fusion is pushed onwards by the strike, till it covers the whole surface of an even thickness, which of course is governed by the depth of the ledge round the table.

Milled sheet lead is made by rolling a cast plate of the metal between large iron rollers, turned by machinery; the rollers are set closer together, till the lead is reduced by rolling to the requisite degree of thinness. Milled sheet lead is more dense, or more equally so, and consequently more durable than sheet lead.

Lead pipes are formed by bending sheet lead round cylindrical moulds, and soldering the edges. If the pipe is to have a diameter of less than four or five inches, it is made

by "casting a thick cylinder of lead with a small bore, and about five or six feet in length; a long smooth iron rod a little larger than the bore of the cylinder is forced into this, and the cylinder is gradually drawn through a succession of circular holes decreasing in diameter, in a steel plate, by means of a powerful draw-mill, worked by a steam-engine. The lead is by this process extended out over the iron rod, which preserves the bore of the pipe of an equal diameter, and when the pipe is sufficiently reduced in thickness, the *rod*, or *triblet*, is forcibly drawn out, and the pipe left with a smooth bore, ready for use."

Lead readily unites with several other metals. When fused with gold it enters into intimate combination, and when even in a small quantity it greatly impairs the colour and the ductility of that metal. It forms a very fusible alloy with silver, but the tenacity and hardness of that metal is much impaired; this is also the case with platinum. Lead forms with copper a brittle grey alloy. Various opinions have been entertained as to whether lead and iron enter into combination with each other or not. This metal also unites with potassium, sodium, cobalt, bismuth, arsenic, mercury, and most of the other metals. Lead mixed with antimony in the proportion of 16 to 1, with a little copper or tin forms the very important alloy, *type-metal*. It would be almost impossible to enumerate all the uses to which lead is applied in the arts, in medicine, and in the common wants of Man.

"Earth's seeming caves their wealth reveal;
Fire bears his banner on the wave;
He bids the mortal poison heal,
And leaps triumphant o'er the grave.

"With thoughts that swell his glowing soul
He bids the ore illume the page,
And proudly scorning Time's control,
Commerces with an unborn age."—SPRAGUE.

CHAPTER XXVII.

LITHIUM.

LITHIUM is a white metal, somewhat similar to sodium, and very oxidizable. It fuses at 356 degs.; its specific gravity is 0·59, and it is therefore the lightest solid known. It has a very acrid taste; and, in some respects, it acts as a caustic. It was first obtained by Sir H. Davy, from the newly discovered alkali, lithia.

It is obtained by electrolyzing in contact with mercury, the hydrate of lithia, and then decomposing the amalgam by distillation; or by fusing pure chloride of lithium in a small thick porcelain crucible, and decomposing the fused chloride by electricity. Lithium has never been seen in any considerable mass, partly on account of its rarity, and partly because of the very great rapidity with which it returns to an oxidated state as fast as it is formed by the action of the pile.

It exists in several minerals, such as spodumine, petalite, lepidolite, and triphylline; and it may sometimes be met with in minute quantities in mineral springs. Its *stony* origin is indicated by its name.

Lithia, the oxide of lithium, consists of 100 parts metal + 123 parts oxygen; it has a white colour; is fused by a red heat, and in that state is transparent; it changes vegetable blue to green, and reddens vegetable yellows.

CHAPTER XXVIII.

MAGNESIUM.

MAGNESIUM is a white, malleable metal having a specific gravity of 1·75; it decomposes water, but not with such rapidity as the other alkaline metals, owing doubtless to the insolubility of magnesia; it absorbs oxygen, when

exposed to the air, and is converted into magnesia. It is fusible at a red heat; it is almost as volatile as zinc, and may therefore be purified by distillation.

This metal is prepared only as a chemical curiosity, for it is put to no use in the arts; it may be obtained from its chloride by heating it with potassium or sodium.

Magnesia, the oxide of magnesium, is a very soft, white, light earth, with little taste or smell; unalterable in fire; insoluble in water, and it is 2·33 times heavier than that liquid. The employment of magnesia in medicine has rendered it universally known, but beyond that use it contributes very little to the wants of mankind.

Epsom salt, or *sulphate of magnesium*, occurs in sea water, and in that of many mineral springs. It is now manufactured in large quantities, by acting on magnesian limestone by diluted sulphuric acid, and separating the sulphate of magnesia from the greater part of the slightly-soluble sulphate of lime by the filter. Epsom salt has a nauseous bitter taste, and, like many other neutral salts, purgative properties.

Meerschaum, from which pipe-bowls are often made is a silicate of magnesia.

CHAPTER XXIX.

MANGANESE.

Manganese is a brilliant dark grey metal, of a granular texture, possessing considerable hardness, and great brittleness, though it is not pulverizable; it is so difficultly fusible that no heat, yet tried, has caused it to run into masses of any considerable magnitude. Morveau states that it melts at 160 degs. Wedgewood, or a fusing point somewhat higher than iron. It is not attracted by the magnet, unless a small portion of iron be alloyed with it. It is 8·013 times heavier than water.

When thrown into water, it decomposes that liquid, becomes green, having absorbed 0·15 of oxygen; if it be

exposed to the influence of the atmosphere, it turns brown, and contains 0·25 of oxygen; the oxide in a native state contains 0·4, hence its importance in the production of oxygen gas.

This metal gradually oxidates and crumbles into powder by mere exposure to the atmosphere. Very various opinions have been maintained as to how many oxides there are belonging to this metal: Davy admits only two, John three, Berzelius five, which number he has subsequently reduced to four, and some chemists state that there are seven. We will, however, only mention three:—the green, brown, and black; and give to these respectively the names of protoxide, deutoxide, and peroxide of manganese.

The *protoxide*, or *green* oxide is formed when manganese is thrown into water; the water is decomposed, and the metal is converted in a green powder. It consists of 87 metal + 13 oxygen. The *deutoxide*, or *brown* oxide, may be obtained by exposing the green oxide to the influence of the atmosphere; it is composed of 80 parts manganese + 20 parts oxygen. The *peroxide*, or *black* oxide, is found in nature in great abundance; it may be formed by dissolving manganese in nitric acid, and evaporating to dryness: it consists of 71·33 metal + 28·67 oxygen.

Manganese was first known to Bergman and Scheele, in the year 1774. The oxide is the chief ore from which this metal is procured; the other ores are the sulphuret, and a phosphate, in which there usually exists some portion of iron, but these ores are rare. The manganese which is used in England is obtained in the state of black oxide from Somersetshire, Devonshire, Cornwall, and Ireland. It is very abundant in America, and various parts of the continent, especially in Germany and Sweden.

The ore of manganese, known in Derbyshire by the name of *black wadd*, is remarkable for its spontaneous ignition when in contact with oil; it possesses a dark brown colour, approaching to black, a friable earth appearance, partly in powder, and partly in lumps.

Manganese unites with most of the other metals, but it cannot be amalgamated with mercury.

This metal is very extensively employed; most of the oxygen gas used by the chemist is obtained from its black oxide. It is used in glass making, both for imparting to

glass a purple or violet colour, and also for destroying all colour, rendering the glass colourless; this difference of effect depends upon the metal possessing the property of absorbing different doses of oxygen. It is also employed by the bleachers of fustian and muslin for preparing chlorine or oxy-muriatic acid.

CHAPTER XXX.

MERCURY, OR QUICKSILVER.

MERCURY is found in the native state, or amalgamated with silver, or in combination with sulphur. The sulphuret, called *cinnabar*, is the principal ore, from which the supply is procured. To extract the metal from cinnabar, or the *sulphuret of mercury*, this ore is mixed with quick-lime, and then submitted to heat; the lime combines with the sulphur, and the metal, which sublimes from the mixed mass, is collected in receivers.

The largest quicksilver mine in the world is that of Idria, a town in Hungary; it has been constantly worked for more than three centuries. It is supposed to afford about 100 tons of mercury annually; and 1000 men are employed in it. The ore raised yields better than 8½ per cent. of metal; but sometimes the pure metal is found gushing from the rock in a stream, in this way 36 pounds have been gathered in the course of 6 hours. The miners suffer very much from the great heat of the mines, and the unwholesome vapour of the metal, with which they become so impregnated, that if they rub a piece of brass with their fingers, it turns white like silver; they soon lose their teeth from salivation, and nearly all die before they are 40 years old. The inhabitants of the neighbourhood suffer much from tooth-ache; their cattle cannot be reared, nor will their fruit or grain ripen.

Mercury is also found in Peru, the East Indies, Almaden in Spain, Lower Austria, Sweden, and China. The largest

mine in Peru, is that of Guanca Velica, which is 170 fathoms in circumference, and 480 deep; in this profound abyss are houses, streets, and even a chapel, in which religious ceremonies are performed on all festivals. The mine is lighted up with thousands of flambeaux. The miners are principally criminals, who confined *naked* in this dreary abode, very soon die of the most horrible convulsions.

> "Thus in the dark Peruvian mine confined,
> Lost to the cheerful commerce of mankind,
> The groaning captive wastes his life away,
> For ever exiled from the realms of day;
> While all forlorn and sad he pines in vain,
> For scenes he never shall possess again."

There are also very rich mines at Almaden, in Spain, a small town of La Mancha, situated in the range of the Sierra Morena; they yield annually two and three millions of pounds of mercury, and nearly 1000 men are employed in operations carried on either underground or at the surface. Pliny states that the Greeks imported cinnabar, or sulphide of mercury, from Almaden, 700 years before Christ.

Mineralogists have divided the ores of this metal into five species:—The first, *native mercury*, is found but in small quantities; it is met with in Peru, and in some places in Europe. The second, *native amalgam*, which consists of 64 parts mercury and 36 parts silver, is found in Hungary, and in the Palatinate. The third species, *horn ore*, or *corneous mercury*, is composed of 76 mercury, 16 muriatic acid, and 8 sulphuric acid; it was first discovered about 30 years ago in the mines of the palatinate. The fourth, or *mercurial hepatic ore*, consists of 82 mercury, 14 sulphur, 2 carbon, and a small portion of each of the following substances:—viz., silica, alumina, oxide of iron, copper, and water. It occurs at Idria, at Almaden, and in Siberia. Of the last species, *native cinnabar*, there are two kinds; viz., the *dark-red* and the *bright*. These are found in various parts of Europe, Asia, and South America, and are composed of *about* 85 mercury and 15 sulphur.

Mercury, when pure, in the ordinary temperature of the atmosphere, is a fluid metal; hence its common name of *live* or *quick* silver, a translation of the old Latin name *argentum vivium*, alluding to its mobility and brilliant silvery

aspect. Owing to the fluidity of this metal, it is transported in iron jars, leather bags, or, as from China, in short joints of bamboo.

It becomes solid at 39 degrees below the zero of Fahrenheit's thermometer, and is then both malleable and ductile. Its specific gravity at 60 degs. *above* zero is 13·568; at 40 degs. *below* zero it is 15·612. It boils rapidly at the temperature of 656 degs., and is gradually converted into an invisible and elastic vapour like air. It has, when fluid, the appearance and brilliancy of melted silver; in this state it has neither taste nor smell, and is neither ductile nor malleable. Its most remarkable property, is, that, if it be divided into small parts, each of these parts will assume a globular form; it is so extremely divisible, that it may be strained by moderate pressure through the pores of leather, and thereby freed from dust and some other impurities.

As regards the malleability of *frozen* mercury, some has lately been reduced, at Hudson's Bay, to sheets as thin as paper, by beating it upon an anvil that had been previously reduced to the same temperature. When a mass of this frozen mercury was plunged into a glass of warm water, the metal became fluid, while the water was instantaneously frozen; by the rapidity of this change, the glass was shivered to atoms.

Mercury is not perceptibly altered in the ordinary temperature of the atmosphere; but when heated to 600 degs. Fahrenheit, it gradually becomes oxidized. It combines with oxygen in two proportions, forming the *black*, and the *red* oxides of this metal. The *black*, or *protoxide*, may be obtained by agitating mercury with atmospheric air, when it becomes converted into a black powder which is the protoxide. It may likewise be prepared by decomposing the salt, called *calomel*, or *muriate of mercury*, by a solution of potash. It is an insipid black powder, insoluble in water, and containing about 4 per cent. of oxygen.

The *red oxide*, *deutoxide*, or *red precipitate*, is obtained by exposing mercury to such a heat as may cause it to rise quickly in the vaporous form, when it gradually is converted into a brilliant mass of a scarlet red colour, formerly known as *precipitate per se*, or *calcined mercury*; it has an acrid metallic taste, is very sparingly soluble in water, and contains about 8 per cent. of oxygen. It may more readily be

prepared by dissolving mercury in nitric acid, evaporating the solution to dryness, and gently heating the salt almost to redness, by which nitric acid fumes exhale, and the red oxide is left possessing a fine scarlet colour.

This metal was well-known to the ancients; by them it was termed *hydrargyrum*, or *water silver*, and was used for several useful purposes. Theophrastus, an ancient Greek philosopher, who lived about 300 years before Christ, was acquainted with it, and knew how to obtain vermillion from it. Dioscorides and Pliny mention it as being known in their time; the former shows how it may be obtained by sublimation from cinnabar; and the latter states that it existed native in the mines of Spain, and was well acquainted with the readiness with which it combines with gold.

Several salts and other combinations of this metal are chiefly employed for medicinal purposes; such are—*calomel*, or mild *muriate of mercury*, which is prepared by triturating fluid mercury with corrosive sublimate, and then submitting the mixture to sublimation; *corrosive sublimate*, which is a bichloride of mercury, and is obtained by heating mercury in chlorine, when it burns with a pale red flame, and a substance is formed which is corrosive sublimate; *red precipitate* or oxide formed by means of nitric acid; *turbith mineral*, which is a sub-sulphate of mercury; *Keyser's pill*, an acetate; *precipitate per se*, which is a true oxide of the metal; *Ethiop's mineral*, which is the black sulphuret, consisting of 100 mercury + 8 sulphur, and *cinnabar*, which is the red sulphuret, composed of 100 mercury + 16 sulphur.

The uses of mercury in the arts, and in experimental philosophy, are numerous. The fine pigment called *vermillion*, which, besides being used in painting, is also employed for colouring sealing-wax, is prepared by fusing 100 mercury and 16 sulphur; the Dutch are considered the most successful of all manufacturers of vermillion, it is therefore extensively imported from Holland. Owing to the readiness with which mercury combines with gold and silver, it is extensively employed in separating those metals from their several ores, the mercury being easily disunited by distillation. The combinations of mercury with the other metals are called *amalgams*. Amalgams of silver and another metal, cadmium, are employed for stopping teeth. Mercury is used also for silvering mirrors, for water-

gilding, and for making barometers and thermometers.

"In tubes of glass mercurial columns rise,
Or sink, obedient to th' incumbent skies;
Or as they touch the figured scale repeat
The nice gradations of circumfluent heat."—DARWIN.

A *fulminating powder* has been made from this metal, which is in great use in the making of percussion caps.

The salts of mercury are colourless or white, and are very poisonous, the best antidote for them is the white of eggs, with which they form insoluble compounds.

CHAPTER XXXI.

MOLYBDENUM.

THERE are two ores of molybdenum:—the *sulphuret*, and the *oxide*. The sulphuret of molybdenum occurs in very great abundance in America; it is also found in Cornwall, France, Saxony, Norway, Sweden, Greenland, and Peru. It possesses a bluish-grey colour, and the metallic lustre; it consists of 60 metal + 40 sulphur. It is known by the name of *molybdena*, and was first analyzed in 1778, by Scheele, who found that it contained sulphur, and a white powder, which he called *acid of molybdena*. The *oxide* is of a yellow colour, and is only met with in very small quantities surrounding the sulphuret.

Molybdenum was first obtained in the metallic state by Hielm in 1782, by subjecting the oxide, well mixed with linseed-oil, to an intense heat. It is a brittle metal of a greyish-white colour, possessing a specific gravity of 8·611. Hitherto it has only been obtained in separate globules or grains. It is not altered, though kept in water. The effect of air upon it is unknown. When it is heated in open vessels, it absorbs oxygen from the atmosphere, and is converted into the white or protoxide.

There are four oxides of Molybdenum. The *protoxide*, which is *brown*, may be obtained by dissolving the metal in

powder to a red heat. By exposing it to a longer and more intense heat it is converted into *violet brown* powder, which is considered by Bucholz as the *deutoxide*. The *blue oxide*, or *molybdous acid*, may be obtained by carrying the heat a little higher. It turns vegetable blues to red. The *white oxide*, or *molybdic acid*, may be procured by roasting molybdena for some time, dissolving the grey powder in ammonia, and mixing nitric acid with the solution; the oxide is then precipitated in fine white scales, which after fusion and sublimation become yellow. This also converts vegetable blues to red, though in not so powerful a manner as the blue oxide. It consists of 2 parts molybdenum and 1 part oxygen.

Molybdenum combines with several of the metals, forming brittle or friable alloys, but none of these have been brought to any use; it is not acted upon by the acids, except the nitric and muriatic.

CHAPTER XXXII.

NICKEL.

Nickel was first recognized as a distinct metal, by Cronstedt, in 1751; and in 1775, its properties were examined by Bergman. It being obtained from an ore which occurs in different German mines, and which is called *kupper-nickel* (false or base copper), because it resembles copper, although no copper can be extracted from it, and the miners, after having tried in vain to obtain some, thought that the ore was bewitched,—the name of *Nickel* was given to this metal by its discoverer. Nickel is also frequently found with cobalt. Native nickel has been found in Saxony and Bohemia, but only in small quantities.

When pure, nickel is white like silver, but it has a very pale tinge of yellow. It admits of being finely polished, and possesses then a metallic lustre between steel and platinum. Its specific gravity when cast is 8·279; when hammered, it is increased to 8·820. It is very hard and

infusible, requiring a heat of 160 degs. of Wedgewood in order to melt it. It is like iron attractable by the magnet; in fact, magnetic needles have been made of purified nickel, and have been more highly esteemed than those of steel, on account of their being less liable to be affected by a moist atmosphere.

> "Thus turns the needle to the pole it loves
> With quick librations, trembling as it moves."

This metal is malleable while cold, but it cannot be heated without absorbing oxygen from the air, which renders it brittle. It is not acted upon by either air or water, at the ordinary temperatures of the atmosphere; if, however, it be exposed to the air, in an intense heat, it is changed into an oxide of a dark brown colour, which imparts to porcelain an indestructible beautiful grass green.

There are two oxides of nickel. The *protoxide*, which possesses a *bluish-brown* colour, may be obtained by adding potash to the solution of the nitrate or sulphate, and drying the precipitate; it is composed of 78 nickel + about 22 oxygen. The *peroxide* was obtained by Thernard by passing a current of chlorine through the protoxide diffused in water; a *black* insoluble powder was precipitated, which was the peroxide. It consists of 100 nickel + 39·44 oxygen.

It is remarkable that, although nickel is one of the least abundant of the metals, yet it enters into the composition of meteoric iron, and of all those stony substances which have fallen from the atmosphere at various periods, on every portion of the earth; hence they are called *meteoric stones*. It is believed by many that they are ejected from a volcano in the moon.

The difficulty with which this metal is worked, has prevented it from being more generally known. Its principal use is in the preparation of several beautiful alloys, such as *German silver*, or *argentane*, which consists of 25 nickel, 50 copper, and 25 zinc, and which is extensively employed in the manufacture of spoons, forks, and other articles; and *white copper*, which is brought from China, and is composed of 31·6 nickel, 40·4 copper, 25·4 zinc, and 2·6 iron; it is called also Chinese *hackfong*. The oxide of nickel imparts a fine hyacinth colour to glass, and is therefore used in making artificial gems.

The sulphuric and muriatic acids have little effect upon nickel; the nitric and nitro-muriatic acids are its best solvents.

CHAPTER XXXIII.

NIOBIUM.

Niobium is a very rare metal, discovered by H. Rose, in 1845, and said by some to be found with tantalium, which it resembles in some of its properties, in the tantalite of Bodenmais in Bavaria: when the supposed tantalic acid from this source is mixed with charcoal, and heated in a current of chlorine gas, a sublimate is obtained which is a yellow, very fusible and very volatile substance,—the chloride of pelopium, and a white, infusible, less volatile body, the chloride of niobium. The niobium may be obtained in a finely divided metallic state by the action of ammonia on the chloride at a high temperature; thus prepared it is black, pulverulent, not acted upon by water, but burning, when heated in the air, to niobic acid, which becomes dark yellow, and has a specific gravity, varying from 4·56 and 5·26.

CHAPTER XXXIV.

NORIUM.

This is another rare metal, recently discovered by Svanberg, who states that an undescribed metallic oxide exists in certain varieties of zircon, to the metal of which he gave the name of Norium.

CHAPTER XXXV.

OSMIUM.

Osmium derives its name from *osme* (smell) on account of its oxide having a peculiar aud pungent smell, somewhat similar to chlorine. It was discovered by Professor Tennant in 1803, in the black powder which is left after that crude platinum has been digested in nitro-muriatic acid. Oxide of osmium may be procured by mixing the black powder with nitre, and distilling at a low heat; oxide of osmium rises into the neck of the retort, in the form of an oily fluid, which after being cooled is a solid, semitransparent mass, soluble in water.

The osmium may be obtained if the pure oxide, dissolved in water, be shaken with mercury, when it will lose its strong smell, and a perfect amalgam is formed; by squeezing the superfluous mercury through leather, and distilling the remainder, a dark grey or blue powder is left which is the osmium.

It has never yet been sufficiently heated to reduce it to a mass; therefore nearly all of its physical properties are unknown. Osmium is unchangeable even in the most intense heat, unless exposed to the air, when it imbibes oxygen, and is converted into a volatile oxide, which is a solid, colourless, semitransparent mass, having a sweet taste, a peculiar odour, and a kind of oily appearance. It is soluble in water; the solution is colourless, does not alter vegetable blues, and strikes first a purple, and afterwards a blue, with an infusion of nut-galls. When combined with potash it gives an orange coloured solution in water, which imparts to the skin an indelible stain of a dark colour.

Osmium has not been applied to any useful purpose, and its combinations are but little known.

CHAPTER XXXVI.

PALLADIUM.

PALLADIUM (so named on account of its being first obtained in a separate state, about the same time that the new planet *Pallas* was discovered) was first procured by Dr. Wollaston, in the year 1803, from crude platinum.

It is obtained by dissolving a sufficient quantity of crude platinum in nitro-muriatic acid, and adding a solution of prussiate of mercury, which will gradually precipitate a yellowish white powder, which is prussiate of palladium. If this powder be washed, dried, and exposed to heat, a white mass is left, which is palladium.

It is a white, or rather steel-grey, malleable and ductile metal, somewhat resembling platinum in its appearance, having a specific gravity of about 11·86, and a fusing point somewhat below that of platinum. It is flexible, but not very elastic; when broken it has a crystalline texture. It does not alter in the air, but when kept strongly heated, its surface acquires a blue tarnish; a more violent heat causes it to resume its original metallic appearance.

The only known oxide of palladium was formed by Berzelius, who heated the filings of the metal with potash and nitre; its colour was chesnut-brown.

This metal is soluble in the sulphuric, nitric, muriatic, and nitro-muriatic acids; the solutions have each a red colour.

Palladium possesses the property of destroying the colour of gold, even when alloyed with that metal in the very small proportion of one to five or six.

On account of the very small quantities of palladium which have been obtained, it is not much used, and its combinations are but little known. It is sometimes used for scale pans, chronometer-balances, and in stopping decayed teeth.

CHAPTER XXXVII.

PELOPIUM.

PELOPIUM is a very rare metal, which was discovered in the year 1845, by H. Rose. It exists as an oxide in combination with the oxide of niobium in the *tantalite* of Bodenmais, in Bavaria; if the supposed tantalic acid from this source be mixed with charcoal and heated to redness in a current of chlorine gas, a sublimate is obtained, which is a yellow, readily fusible, and very volatile substance, the chloride of pelopium, and the white, infusible, less volatile chloride of niobium. The pelopium may be procured in a finely divided state by the action of ammonia upon its chloride, at a high temperature; thus prepared it is black, pulverulent, not acted upon by water, but burning when heated, in contact with the atmosphere, to pelopic acid, which has a specific gravity varying from 5·79 to 6·37.

CHAPTER XXXVIII.

PLATINUM, OR PLATINA.

THIS METAL was discovered in 1741 by Mr. Wood, assay-master in Jamaica; its name is derived from the Spanish as a diminutive from *plata* (silver), in allusion to its silvery lustre; hence *platina*, and its Latin, *platinum*.

Platinum is comparatively a rare metal, and is found in a metallic state, either nearly pure, or in combination with silex, chromium, palladium, rhodium, osmium, iridium, silver, gold, copper, lead, and iron. It usually is met with in small roundish flattened grains, about the size of sand, but it has occasionally been found in granular pieces as large as a pea. A specimen of *native platinum* was presented by M. Humboldt, to the King of Prussia, larger than a pigeon's egg; it weighed 1·088 grains, and had a specific gravity of 18·947. The largest mass that has ever been found, weighs

more than a pound and three quarters, and is deposited in the Royal Museum at Madrid.

It occurs in the Ural Mountains in Russia, in the silver mines of Guadalcanal, in the province of Estramadura, in Spain; in Ceylon; in the gold mines of Brazil; in the island of St. Domingo; in Choco, and in the mines of Taddo, near Rio-de-la-Plata, in Peru; in New Granada; and in several parts of South America, particularly at Santa Fé, near Carthagena.

The crude platinum is to be dissolved in nitro-muriatic acid, precipitated by muriate of ammonia, and exposed to a violent heat; then the acid and alkali are expelled, and the metal reduced in an agglutinated state, which is rendered more compact by pressure while red hot.

Platinum is the heaviest, not only of all metals, but also, of all solids, as it has a specific gravity of 21·53, which is increased by hammering to 23·66; it is nearly as white as silver, but not so brilliant as that metal; it resists the heat of our most powerful furnaces, but it submits to the heat produced by the oxy-hydrogen blow-pipe; with great labour, it may be rendered malleable, so as to be worked into vessels, like other metals. Like no other metal, except iron, it possesses the valuable property of *welding;* two pieces of platinum may be united by laying them in contact, and hammering them, while they are raised to an intense heat. It has great tenacity, and is so ductile that it has been drawn into wire by Dr. Wollaston 1-18,750th of an inch in diameter, and it supported one grain and one third without breaking; a wire 0·078 inch is capable of supporting 274·31 lb. avoirdupois. It may, by means of powerful rollers, be reduced to sheets of almost any thinness that may be required. It does not rust or corrode when exposed to either air or water; and is destitute of taste or smell. The ordinary acids, and the immense quantity of chemical re-agents, have likewise no action upon platinum; aqua regia alone dissolves it, and caustic potassa, when fused upon it, oxidizes it. It is a very slow and bad conductor of heat. A great many alloys have been formed with this metal; it may be amalgamated with mercury, but it diminishes the fusibility of this, as well as that of all other fusible metals.

The *green* and the *brown* are the only two oxides of platinum known. The *green oxide,* or *protoxide,* is obtained

by gradually heating the brown oxide, by which the separation of a quantity of oxygen is effected. It is composed of 93 platinum + 7 oxygen. The *brown oxide*, or *peroxide*, may be procured by pouring lime water into the solution of platinum in nitro-muriatic acid; a brown powder is precipitated, which must be dissolved in nitric acid, the solution evaporated to dryness, and the acid expelled by a cautious application of heat. A brown powder remains which is the peroxide; it consists of 87 platinum + 13 oxygen, is insoluble in water, and therefore tasteless; it may be decomposed by a red heat.

Fulminating platinum, which was discovered by Mr. Edmund Davy, may be prepared by pouring aqueous ammonia into a solution of the sulphate in water; the precipitate which falls is to be washed, put into a mattress with potash-ley, and boiled for some time; it must then be filtered, washed, and dried. A brown powder is obtained, lighter than fulminating gold: this is fulminating platinum. When heated to 400 degs. it explodes, but does not detonate by friction or percussion.

Notwithstanding all the valuable properties which this metal possesses, it is of little use to man, owing to its great scarcity, which has rendered it very expensive. Although it is some five times more costly than silver, it is of great value for chemical utensils, such as crucibles, spoons, small tongs, rods, &c., because it possesses the two-fold power of resisting high temperatures and chemical action. It is used also for retorts for the concentration of sulphuric acid; and to make mirrors for reflecting telescopes.

When beaten into thin leaves, it has sometimes been applied to porcelain in the same manner as leaf gold. A part of the Russian coinage is cast in this metal. It is employed to obtain instantaneous light in Doebereiner's lamps, in the state of a fine powder called *spongy platinum*, which is procured by precipitating it in muriate of ammonia.

CHAPTER XXXIX.

POTASSIUM.

EARLY in October, in the year 1807, Sir H. Davy succeeded in decomposing common potash, by the agency of voltaic electricity, and found that it consisted of oxygen and a peculiar metal which he named potassium, in the proportion of 100 of potassium and 20 of oxygen.

The metal has since been obtained in large quantities, simply by keeping potash in fusion with intensely hot iron.

It is found in nature in great abundance, but only in combination, and generally as potash. Potash was formerly procured by burning vegetables in large iron pots; from which circumstance it acquired the name of *potash;* and from this, the name of the metal—*potassium*—is derived. The metal occurs in small quantities in animals, in natural waters, and in the sea; but, of course, not in a pure state.

Potassium is a metal of a brilliant white colour, with a shade of blue; it is solid at the ordinary temperature of the air, but readily becomes soft and malleable in the hand. At 32 degs. it is hard, brittle, and crystalline; at 50 degs. it is a soft malleable solid; at 70 degs. it is semi-fluid, having in small globules a resemblance to mercury; at 150 degs. it is perfectly fluid, and may be distilled at a low red heat, forming a vapour of a green colour. Its specific gravity is only 0·865; it is therefore not only considerably lighter than water, but also lighter than any known liquid. It is a conductor of electricity.

Potassium possesses the strongest attraction for oxygen of all known substances, and it produces such a condensation of it, that the oxides of potassium are denser than the metal itself. To preserve it unchanged, it is therefore kept under naphtha, that substance not containing any oxygen. When thrown upon water it kindles spontaneously, and, burning with a red flame mixed with violet, it moves rapidly over the

surface of the water, amid explosions, and the evolution of a quantity of gas: the water is found to be alkaline.

"When thrown upon water, this metal ignites,
And leaps o'er its surface with violet ting'd lights;
Or, if upon ice this substance you cast,
It will melt by degrees and be dissolved at last."

EULALIA GURSON.

When a piece of potassium is laid upon ice, it takes fire as if upon water, melting a hole in it with great rapidity; when moderately heated in air, it ignites, burns with a red flame, and throws off alkaline fumes.

This metal may be united with oxygen in various proportions. The *protoxide of potassium*, *potassa*, or *potash*, is formed when the metal is thrown upon water; a violent action ensues, the water is decomposed with the evolution of flame, while the protoxide of potassium remains in solution. It consists, as we have before stated, of 100 metal + 20 oxygen. The *peroxide*, called by some the *tritoxide*, contains 100 potassium + thrice as much oxygen as the protoxide, or 60; it is procured by burning potassium in the open air, or in oxygen gas, when it is converted into an orange-coloured substance, which is the peroxide.

Potassium readily unites with many of the other metals, particularly with mercury; the amalgam is capable of dissolving all other metallic substances. Its alloys are, however, soon destroyed in the open air, or in water, while the potassium is changed into potash. At a red heat, it decomposes glass, and is even capable of reducing all the metallic oxides.

Nitre, *saltpetre*, or *nitrate of potassa*, is an important compound, and a natural product, being disengaged by a kind of efflorescence from the surface of the soil in certain dry and hot countries. *Gunpowder* is made by intimately mixing together 75 parts nitrate of potassa, 15 charcoal, and 10 sulphur.

The principal supply of potassium is brought from Russia and America.

CHAPTER XL.

RHODIUM.

RHODIUM was discovered by Dr. Wollaston, in 1803, associated with palladium, in crude platinum, which contains about one part in 250 of this metal; he called it *rhodium*, from *rhodon* (a rose), because the salts formed with it gave rose-coloured solutions. Dr. Wollaston's process for obtaining it is somewhat complicated: —"Crude platinum is dissolved in nitro-muriatic acid, and the platinum precipitated by sal ammoniac. A piece of clean zinc is immersed into the residuary solution, which throws down a black powder. This black powder is digested with dilute nitric acid in a very gentle heat, to dissolve some copper and lead with which it is frequently contaminated. It is then dissolved in nitro-muriatic acid, common salt is added to the solution, and the whole is gently evaporated to dryness. The residuum is washed repeatedly with small quantities of alcohol, which dissolves two salts, consisting of the oxides of platinum and palladium, in combination with common salt. There remains behind a deep red coloured substance, consisting of the oxide of rhodium, united to common salt. By solution in water, and gradual evaporation, rhomboidal crystals of a deep red colour are obtained. These crystals being dissolved in water, and a plate of zinc immersed into the solution, a black powder precipitates, which being strongly heated with borax, becomes white, and assumes a metallic lustre. In this state it is rhodium."

Rhodium is a white metal, tinged with yellow; it is rather harder than iron, but more brittle; and, iridium excepted, it is the most infusible of the metals. It is 10·649 times heavier than water.

By different modes of treatment three oxides may be obtained of this metal:—The *black oxide*, or *protoxide*, may be procured by heating rhodium with access of air; the *light brown oxide*, or *deutoxide*, may be procured by heating powdered rhodium with potassa and a small quantity of

nitre; the *dark red*, or *peroxide*, which may be obtained by precipitation from the soda-muriate by potash, exists in the state of a hydrate.

Rhodium unites with all the metals tried by Dr. Wollaston, except mercury, with which it cannot be amalgamated. It resists the action of all the acids.

Were it not for its great scarcity, rhodium would most probably be of great value in the arts, on account of its hardness. It is said to be used for nibs of gold pens.

This metal has, hitherto, only been found in combination with the native platinum which comes from Peru.

CHAPTER XLI.

RUBIDIUM.

Rubidium was discovered by Bunsen at about the same time as cæsium, like which metal, it was at first only found in one or two mineral waters, but has since been shown to be widely distributed in the vegetable as well as in the mineral kingdom. This newly recognized metal has been obtained in considerable quantities from the beet-root salt, and it has lately been found by M. Grandeau in tea, coffee, grapes, tobacco, and crude tartar. The tobacco which he employed came from Kentucky and Havannah: the leaves having been acted upon by water, which was afterwards evaporated, he calcined and tested the residue by spectrum analysis, and found that it contained potassium, a small proportion of lithium, and a notable quantity of rubidium. Tea and coffee yield no trace of lithium, but are much richer in rubidium than tobacco.

CHAPTER XLII.

RUTHENIUM.

RUTHENIUM is a grey, very hard, brittle metal, found in the ore of platinum. It was discovered by Klaus in 1844. It is so infusible that it will not yield to the action of the oxy-hydrogen blow-pipe; it has a specific gravity of 11 to 11·4.

This metal may be combined with several other substances; but, on account of its great scarcity, of its having been so recently discovered, and of its having been examined by only very few chemists, very little more than what we have stated is known about it.

CHAPTER XLIII.

SIDERIUM.

THIS newly recognized metal was discovered in 1863, by Mr. E. Sonstadt, of Loughborough—in the development of his invention for the production, on a commercial scale, of the metal magnesium, which, it is hoped and believed, will, at no distant period, be extensively introduced as a substitute for silver—in the "carcasse" remaining when the chloride of magnesium is obtained by evaporating and igniting the chlorides of magnesium and sodium. Siderium in many of its reactions corresponds almost precisely with iron, for which metal it has probably hitherto been mistaken: the blue, as in the case of iron, is obtained with the prussiates of potash, but, unlike iron, this blue is unchanged, or only turned purple, by the addition of ammonia, whatever the

excess. If the precipitate by an alkali be ignited, it will be reduced to a dark spongy mass before the blow-pipe on charcoal with great difficulty; this mass does not fuse, and is not in the least magnetic. Siderium appears at present, to occur invariably in connection with magnesium, from which it cannot be entirely separated; the discoverer, however, succeeded in separating the oxide of the metal, but the process is so tedious that half a grain in three weeks is about the present rate of production.

CHAPTER XLIV.

SILVER.

This metal has been known and employed from the very remotest ages; it was used in commerce 1100 years before the foundation of Rome: see Genesis xxiii., 16. Pliny states the Romans merely considered it as a piece of elegance to be consumed in the ornaments of coaches and in the trapping of horses. Nero and his wife shod their favourite horses with silver and gold.

According to the Scriptures, it was employed in the remotest ages, Gen. xxiii., 15, 16: many utensils were made of it, Gen. xliv., 2; Exod. xii., 35; Numb. vii., 13, x., 2. The first mention of its being used as money is in Gen. xx., 16: the shekels were not coins, but pieces weighed out; see Gen. xxiii., 16; also Jeremiah xxxii., 9. In Job xxviii., we read that it was found in veins; it was obtained (among other places) from Spain, Ezek. xxvii., 12; Jeremiah x., 9.

Silver is found in several parts of the world, especially in Peru and Mexico, in Saxony, Bohemia, Swabia, and Hungary; in France, Spain, Norway, Sweden, Russia, Siberia, China, and Japan. We have no silver mines in England, but it is met with in most of the lead mines of England, Scotland, and Ireland; as well as in the copper mines of Cornwall. The mines of Peru and Mexico yield annually ten times more silver than all the European mines

united. Humboldt states that these mines in the space of three centuries afforded 316,023,883 pounds troy of pure silver; and he remarks that this quantity would form a solid globe of silver 91,206 feet in diameter. A mass raised in one of the Peruvian mines weighed 800 pounds.

The mines of Potosi have long been celebrated: they are in a mountain of that name, situate near the source of the river Plata (*silver*), which derives its name from this circumstance. The mountain which rises to a height of 4,200 feet is filled with silver-ore; it is in the form of a sugar loaf, and is perforated in every direction, in search of the metal. Since the year 1545, when it was opened, its produce has been valued at £235,000,000 sterling. It has been stated that the mines of America alone yield silver, annually, to the value of about £7,250,000 sterling.

It occurs native, as an oxide, and as a sulphuret, as a chloride, and also combined with lead, copper, mercury, cobalt, antimony, arsenic, bismuth, iron, and other substances. A very large proportion of silver is obtained from some native ores of lead, and such ores are known as *argentiferous* (from the Greek, *arguros*, silver). The silver is either procured by *amalgamation* or by *fusion*; the former process is adopted when the ore is rich in silver, the latter when it contains very little of this precious metal. Native silver is occasionally found crystallized in cubes and octahedrons; and sometimes in leaves, threads, or wire. Very frequently the latter are so connected with each other, as to resemble the branches of trees; the ore is then called *dendritic*; but it is usually met with in irregular masses. A rich vein of silver-ore was discovered at Schneeberg, in Saxony, in 1478, and a mass of native silver was cut out, which was so large, that, when melted, it yielded 44,000 pounds of metal.

Silver is the whitest of all metals, and capable of being very highly polished by the burnisher; it is sonorous, destitute of taste or smell, and possesses very remarkable ductility, tenacity, and malleability. It may be beaten into leaves only 1-100,000th of an inch thick, and is the most ductile and malleable of all the metals except gold. Fifty square inches of *silver-leaf* weigh no more than a grain, and the *silver wire* used by astronomers, is only half as thick as a fine human hair. As regards its tenacity, a silver wire

·078 inch thick will support 187·13 lb. avoirdupois, without breaking. The specific gravity of silver is 10·474; a cubic foot weighs about 660 lb. Its fusing point is 1873 degs. Fahrenheit, or, according to Dr. Kennedy, 22 degs. Wedgewood.

By exposure to air, silver does not undergo oxidation, unless exposed to an intense heat. There is only one oxide of silver known with any certainty; it may be prepared by dissolving the metal in an acid, and precipitating it by lime-water, an alkali, or an alkaline earth. Sir H. Davy found that 100 silver combined with 7·3 oxygen in the above oxide.

Silver unites with chlorine, when the metal is heated in contact with the gas. It is generally prepared by adding muriatic acid, or a muriate, to nitrate of silver. It has long been known by the name of *luna cornea*, or *horn silver*, because, though a white powder as it falls down from the nitrate solution, if fused by a gentle heat, it forms a horny-looking substance when it cools; it is composed of 13·75 silver + 4·5 chlorine.

This metal is used principally for ornamental work, for domestic utensils, and for current coin. In its pure state, however, silver is too soft for coin, plate, and most ornamental purposes; it is therefore, in such cases, alloyed with copper in such a proportion that the colour is not much impaired, and it is considerably hardened. The *standard silver* of our coin is formed with 37 parts of pure silver, and 3 parts of copper. A pound of standard silver, which is an alloy of 11 oz. 2 dwt. of pure silver + 18 dwts. of copper (Troy), is coined into 62 shillings. The silver coin of France contains 19 parts of silver to 1 of copper.

Silver being one of the best conductors of heat and of electricity, is preferred to all other metals in the construction of all delicate electrical instruments, where long metallic wires are required. When melted with glass it imbibes oxygen, and imparts to it a fine, and, at the same time, a yellow colour; it is therefore employed in glass staining. *Indelible Marking ink* is made by dissolving ten grains of lunar caustic (nitrate of silver) in half an ounce of gum-water The white powder in percussion caps is likewise a preparation of this metal.

CHAPTER XLV.

SODIUM.

Sodium was first obtained, in 1807, by Sir H. Davy, by slightly moistening caustic soda, by merely breathing upon it, and placing it upon a disc of platinum; he then connected the disc with the negative pole of a powerful voltaic battery, and the upper surface of the soda with the positive pole. The soda was gradually decomposed; oxygen gas was evolved at the positive wire, and the metallic sodium appeared in globules at the parts in contact with the platinum.

A more purely chemical process has been subsequently discovered by Gay Lussac and Thenard, by which sodium may be obtained in greater abundance; this is brought about by subjecting soda mixed with iron turnings to a white heat in a gun-barrel.

Some of the properties of this metal are very similar to those of potassium. It has the colour and brilliancy of silver, is very malleable, and has a specific gravity of 0·972, that of water being 1. Pure sodium is soft at the common temperature of the atmosphere; at 120 degrees it begins to melt, at 180 degrees it is completely fluid, and it requires a strong red heat to volatilize it.

The affinity with, or attraction for, oxygen, of sodium, is not so strong as that of potassium. When exposed to the air it gradually absorbs oxygen, and is soon covered with a coat of oxide of sodium, or *common soda;* but as that alkali does not deliquesce, the nucleus is not so rapidly destroyed as is the case with potassium. If it be fused with dry soda in certain proportions, the *protoxide* of sodium is procured, which has a deep *brown* colour, and (according to Thenard) consists of 100 metal + 33·995 oxygen. The peroxide may be obtained by burning sodium in oxygen in excess, it is of a deep orange colour, and (according to Thenard) is composed of 100 metal + 67·99 oxygen.

When placed upon water, it does not ignite like potassium (unless its motion be restrained by adding gum-water or starch to the water, or unless the sodium be placed on a

piece of metal and a drop or two of water be allowed to fall upon it), but effervesces violently, and swimming upon its surface, gradually diminishes with great agitation, decomposes the water, evolving hydrogen gas, and forming an alkaline solution of soda. With hot water it takes fire at once, and burns with a bright yellow flame. Like potassium, it is best preserved under naphtha.

Sodium may be united with chlorine, but only in one proportion; this is the important substance *common salt*, chemically termed *chloride of sodium*. It consists of 36 chlorine + 24 sodium, and may be directly obtained by combustion, or by decomposing any compound of chlorine, by sodium.

Potassium and this metal may be combined in several proportions; 8 potassium + 1 sodium will swim in naphtha, and like the alloy of 3 potassium + 1 sodium is fluid at the common temperatures of the atmosphere.

This metal occurs in nature in abundance, but always in a state of combination. The chloride is the most important native ore, which, as *rock-salt*, is found in immense beds in the solid crust of the earth; it occurs, also, in a state of solution in the sea, and probably in every natural water. Compounds of this metal are found in several minerals and in most soils; they occur, although in small quantities, in most land plants, but abundantly, as *kelp* illustrates, in those of the sea. It is also found in a state of the chloride in the higher animals who instinctively swallow large quantities of common salt.

CHAPTER XLVI.

STRONTIUM.

In 1807, Sir Humphrey Davy ascertained that *strontia* (which was discovered in 1787, in a mineral taken to Edinburgh, by a fossil dealer, from a lead mine at *Strontian*, in Argyleshire, whence its name is derived) consisted of 100 parts of a metal, which he named *Strontium*, and 18·181 parts of oxygen. He made into a paste with water native

carbonate of strontia, and placed it on a small platinum tray; he then placed a globule of mercury within a cavity made in the surface of the paste. He then connected the platinum with the positive pole, and the mercury with the negative pole of a pile of about 100 double plates. An amalgam of mercury and strontium was thus obtained, which he introduced into a tube of glass made without lead, which was then filled with the vapour of naphtha, bent into the form of a retort, hermetically sealed. He then separated the strontium from the amalgam, by driving off the mercury by heat.

Strontium resembles barium in most of its properties. It is a malleable metal of a pale yellow colour, having a specific gravity of 2·54. It decomposes water rapidly, with the evolution of hydrogen gas; the water is converted into a solution of strontia. When heated in the open air, it burns with a yellowish flame, with the emission of sparks. Its compounds are not poisonous.

This metal may be united with oxygen in two proportions. The *protoxide of strontium*, called *strontia*, and *strontian*, is best obtained by decomposing the nitrate by the aid of heat; it is a *grey*, poisonous, alkaline earth resembling baryta (but is not poisonous), and has a violent affinity for water; by affusion of this liquid, heat is evolved, and so much earth is dissolved that crystals separate on cooling. One hundred parts of strontium unite with 18·181 of oxygen, to form the *protoxide;* and with 36·362 to form the *peroxide*, called by some, the *deutoxide* or *binoxide*.

Strontium is found in the lead mines of Strontian, in Argyleshire, where it occurs as a carbonate, sulphate, &c. It occurs in the rare pale-green mineral *strontianite*, which consists of strontia combined with carbonic acid and water; and which is found in Salzburgh, and at Strontian. It is met with also in *baryto-strontianite*, a pale blue mineral containing some barytes and lime, as well as Strontia and carbonic acid, and occurring only at Stromness, in Orkney. It is found also in *celestine*, which contains equal parts of Strontia and sulphuric acid, near Bristol, in the sulphur mines of Sicily, and in the United States.

This metal forms the chief ingredient in producing that beautiful red-fire, which recently has been introduced in theatrical representations.

CHAPTER XLVII.

TELLURIUM.

TELLURIUM, which derives its name from the Latin *tellus*, the earth, was discovered in 1782 by Müller, of Reichenstein, in the *aurum paradoxicum* or *problematicum*, which has the appearance of an ore of gold, but only very little can be extracted from it. In 1798, Klaproth established its existence not only in this, but also in some other ores of gold found near Zalethna, in Transylvania; he also examined its properties more minutely and gave to the metal the name which it now bears.

It is a white metal, somewhat similar in its appearance to antimony, and possesses great metallic lustre, and a lamellar fracture: it is so brittle that it may easily be pulverized; it is not so good a conductor of electricity as antimony or bismuth. It fuses at a temperature of 620 degs. Fahrenheit; if the heat be increased, it boils, and may be distilled; and when exposed to the action of the blow-pipe on charcoal in atmospheric air, it burns with a pale blue flame, bordered with green, and forms a white vapour which possesses a pungent smell, and which condenses into a white oxide. This oxide heated on charcoal is reduced with a kind of explosion, and soon again volatilized. It appears to contain about 16 per cent. of oxygen.

Tellurium has a specific gravity of 6·115, and is soluble in the nitric and nitro-muriatic acids, but its solutions are decomposed by the addition of water. It forms with oxygen two compounds:—*tellurous acid* and *telluric acid.*

It is a very rare metal found chiefly in the mines of Hungary and Transylvania, occurring sometimes in a native state, but usually in combination with sulphur, arsenic, iron, lead, silver, and gold. *Native tellurium*, which has a tin-white or steel-grey colour, and a metallic lustre, and which is found crystallized, and massive in the mines of Transylvania, consists of 92·55 Tellurium + 7·20 iron + 0·25 gold.

CHAPTER XLVIII.

TERBIUM.

In 1840, Mosander discovered this peculiar metal in the state of oxide in the minerals *gadolinite*, *orthite*, &c., combined with yttria, and the oxide of erbium; but the oxide has not yet been reduced to the metallic state.

The oxide of terbium has hitherto been procured only in small quantities, and its properties are but little known. It may be distinguished from that of erbium in not being changed to a dark orange-yellow colour when heated in contact with the atmosphere. It is insoluble in water, and in the caustic alkalies.

CHAPTER XLIX.

THALLIUM.

This metal has recently been discovered by Crooke, an English chemist and distinguished philosopher, in a residue of impure sulphur. Comparatively little is at present known of this metal, but, we think that this, as well as several others of the new metals, bids fair to become a very useful substance.

CHAPTER L.

THORINUM.

(Called, by some, Thorium.)

This metallic substance was discovered in 1827, by a Swedish chemist, named Berzelius, in a rare earth (which he had found in a mineral occurring near Brevig, in Nor-

way, termed *thorite*), to which he had given the name of *thorina*, in honour of the fabulous deity *Thor*.

If thorina be converted into chloride of thorinum, and heated with potassium, and the mass washed, a deep leaden-grey coloured powder will be obtained, which, when pressed in an agate mortar, will acquire an iron-grey tint and a metallic lustre.

Thorinum is not acted upon by water, either hot or cold. When heated in common air it burns brilliantly, and the *oxide of thorinum*, or *thorina*, is formed, which has a snow-white colour, and is devoid of any trace of fusion; it may also be procured by decomposing the chloride by means of an alkali; when strongly heated its density is 9·402, and it is then insoluble in any acid except the sulphuric, and in that with difficulty.

Thorinum is scarcely at all acted upon by nitric acid, and slowly by the sulphuric; but hydrochloric acid quickly dissolves it, with the evolution of hydrogen gas.

CHAPTER LI.

TIN.

Tin must have been known very early, as it is mentioned in the writings of Moses (Numb. xxxi., 22) as being one of the metals that may "abide the fire" for purification. An alloy of tin and copper was much employed by the ancients for their coins and edge-tools, iron then being comparatively scarce, and very expensive. In Ezekiel xxvii., 12, we read that the Tyrians imported it from Tarshish; and a levelling instrument of tin is mentioned in Zech. iv., 10. This word was also used for a refuse of lead and silver, Isaiah i., 25.

It occurs in South America, in the East Indies, in Germany, and in Saxony; but in England it is chiefly obtained from Cornwall and Devonshire. The Cornish mines have been noted from a very remote period, and seem to have attracted various foreign merchants, and,

in this manner, civilization was brought to our shores, at a period when these islands were wholly barbarous: these mines exceed in richness those of every other part of the world; some idea of their value may, perhaps, be gained from the fact that about 40,000 pounds of gunpowder are consumed every year in blasting the rocks. Tin was imported, by the Phœnicians, at a very early period from Britain. The purest tin, however, is said to come from the peninsula of Malacca.

The principal ores of tin are:—*tin-pyrites*, *tin-stone*, and *stream-tin*. Klaproth, having analyzed *tin-pyrites*, asserts that this ore consists of 34 tin + 36 copper + 3 iron + 25 sulphur + 2 earthy matter; it has a specific gravity of 4·35. *Tin-stone*, the specific gravity of which varies from 6·3 to 6·97, contains from 68 to 78 per cent., and from about 16 to 24 per cent of oxygen, with a small quantity of iron and silica. This, when pure, is the peroxide of the metal. A great quantity of tin, of a superior quality, is obtained in nodules occurring amongst loose stones and fragments which cover the courses of ancient rivers:—hence this is called *stream-tin*. Other masses having concentric bands of colour, like the rings which mark timber and show its age, are termed *wood-tin;* this is a compound of the oxides of tin and iron. It occurs, although sparingly, in Cornwall, and is composed of 91 oxide of tin + 9 oxide of iron; it is, however, very plentiful in Mexico, where it consists of 95 oxide of tin + 5 oxide of iron. Very small specimens of this kind, which exhibit the rings on a minute scale, are called *toad's-eye-tin*. These three last mentioned, however, are only different forms of the same ore.

The ore of tin when taken from the mine is first pulverized in a stamping-mill and washed with running water; it is afterwards roasted in a furnace, and then again washed; after this, the ore, mixed with pit-coal and a small quantity of lime, is strongly heated in a furnace, and kept in a state of fusion for about eight hours, after which time it is drawn off into iron vessels. To get rid of some impurities, which still remain, it is gently heated again, and carefully skimmed; it is then allowed to run into blocks. These form the *block-tin* of commerce, which is not so pure as that obtained from the stream-tin ore; the blocks weigh 3 cwt. each, and are called *pigs: grain-tin* is the term applied to the latter, and likewise to the purest kind of tin in general.

Tin is a metal of a brilliant white colour, of a density of 7·283, and having a fusing point of 442 degs. Fahrenheit: if heated above its melting point, it becomes rapidly oxidized, and is converted into *putty-powder*, or *tin-putty*. It has a slight but disagreeable taste; when rubbed it emits an uncommon smell; and a peculiar crackling noise is heard on suddenly bending it. Tin is not very sonorous: it is flexible, and so malleable, that *tin-foil*, as it is termed, is about 1-1,000th of an inch thick, and it might easily be beaten out into leaves less than half this thickness, if the purposes of trade required it; its tenacity is such that a wire 1-10th of an inch in diameter will support 47·36 pounds. Like lead, it is brittle when heated almost to fusion, and if broken by a blow of the hammer it exhibits a grained or fibrous texture. When exposed to the air tin soon becomes tarnished, but the coat is always extremely thin, and the metal undergoes no further change. Water has no action upon it at ordinary temperatures, but when steam is made to pass over tin heated to redness, a rapid decomposition is effected, the tin becomes oxidated, while hydrogen gas is evolved. When kept in a state of fusion, it soon becomes coated with a greyish matter, which quickly becomes yellow: it is, however, very difficult to oxidize this metal completely by heat and air, without the employment of acids.

Oxygen and tin unite in two proportions, forming the *grey* and the *yellow* oxides. The first of these, termed the *protoxide*, consists of 100 tin + 13·5 oxygen, and may be produced by dissolving tin in muriatic-acid with the assistance of heat, and adding potash in excess to the solution; a white powder is precipitated, which gradually changes into a grey matter, which is the grey oxide. The *yellow oxide*, or *peroxide*, which is composed of 100 tin + 27·2 oxygen, may be procured by heating tin in concentrated nitric acid; a violent effervescence follows, and a white powder is formed, which is the peroxide.

The uses to which tin is applied are very extensive. The use of tin appears to have been known to the Grecians: it is mentioned by Homer in the Iliad; and Pliny states that the Romans learnt the method of tinning their culinary vessels from the Gauls. This metal was also used by them for making those elastic plates which they employed in shooting darts from their warlike machines. The bronze of

the ancients, which was a very beautiful alloy, and sufficiently hard for swords and spear heads, was composed of 12 tin + 88 copper.

If equal weights of peroxide of tin and sulphur be gradually heated together in a retort, some sulphur and sulphurous acid will be disengaged, and a substance formed which is known by the name of *mosaic gold*, or *aurum mosaicum*, formerly called *aurum musivum*, and which consists of 100 parts of metallic tin and 55 sulphur; it is used by artists to give a beautiful colour to bronze.

For the constituent parts of several very important alloys of tin and copper, such as *gun-metal*, *bronze*, *bell-metal*, *speculum-metal*—see the chapter upon copper. Tin diminishes the ductility of copper, but increases its tenacity, hardness, fusibility, and sonorousness.

One of the most important uses to which tin is applied is in the manufacture of *tin-plate*, which consists of a thin sheet of iron coated with tin, and from which such numerous utensils, such as tin cups, kettles, saucepans, &c., are made; the tin preserves the iron from rusting, and at the same time renders it bright in appearance, and more pleasant to use. The plain sheets of iron are first dipped into melted tin and the utensils made afterwards. The process is as follows:—"The sheet-iron is first carefully prepared by being cleaned with acid, and scoured with sand in pure water; then two or three hundred plates are held in a vertical position, and dipped first into grease, and then in a cast iron bath containing about five cwt. of melted tin, where they are allowed to remain for an hour and a half. In that time they get two or three times too much tin to stick to them; the next process, then, is to wash off a portion of it, and to equalize the whole in a vessel of melted grain-tin. They are then cleaned, and rubbed in bins of dry bran until they are highly polished."

Copper is, likewise, frequently covered on one side with this metal. See note on page 45.

Plumbers' solder is composed of equal parts of tin and lead.

Several other important applications of tin might be mentioned, but our space will not allow us to notice any more.

CHAPTER LII.

TITANIUM.

TITANIUM was first obtained, in a state of oxide in the year 1791, by the Rev. Mr. Gregor, in a black mineral found in the parish of Menachan, in Cornwall, which mineral was afterwards termed *menachanite;* it was not, however, much thought of until about four years afterwards, when Klaproth, being unacquainted with Gregor's labours, discovered that what was termed *red schorl* consisted of the same oxide, almost in a state of purity, and it was he who gave to the metal the name it now bears.

Besides being found in *red schorl*, called also *rutile*, or *titanite*, it occurs in *anatase*, *iserine*, and *sphene*; it often forms those beautiful brown filaments which traverse *rock crystal*.

Titanium may be obtained from the native red oxide by fusion with two parts of potash, or six parts of its carbonate, digesting the fused mass in diluted hydrochloric acid, and decanting off, when all the soluble part has been removed: if oxalate of ammonia be then added to this hydrochloric solution, oxalate of titanium will be precipitated, and the iron will remain in solution. The vegetable acid may now be destroyed by calcination, and a yellow oxide will be left, which will become white on cooling. Laugier is said to have reduced this oxide by forming it into a paste with oil, and exposing it to an intense heat; but the reduction of it is no easy task, and it has frequently been attempted without success.

This metal has a colour somewhat resembling that of copper, and considerable metallic lustre, but it is soon oxidized when exposed to heat and air. The *blue*, the *red*, and the *white*, are the only three oxides known; the first, the *protoxide*, may be procured by exposing titanium, when heated, to the open air. The *red oxide*, *deutoxide*, or *red schorl*, is found native, frequently crystallized in four-sided prisms, about 4·2 times heavier than water, hard enough to scratch glass, and containing about 33 per cent. of oxygen.

The *white oxide*, or *peroxide*, may be obtained by melting red schorl with four times its weight of potash, and dissolving the whole in water, by which the peroxide will be precipitated in the form of a white powder, containing about 2 parts titanium + 1 part oxygen. Little else appears to be known about this metal (save that it has a specific gravity of 5·3), on account of its having been obtained only in very minute quantities, and in a very imperfect state of reduction.

Titanium has been employed at the porcelain manufactory at Sevres, near Paris, and it produces on china a brown colour of greater richness than can be obtained by any other means.

CHAPTER LIII.

TUNGSTEN.

The term *tungsten*, signifying *heavy stone*, was first applied by the Swedes to scheelium or wolframium, on account of its high specific gravity: this mineral was analyzed by Scheele in 1781, and found by him to contain lime and a white pulvurent substance, which he supposed to be a peculiar acid, and which was considered by Bergman to be a metallic oxide. The oxide was afterwards found by the D'Elhuyarts (who succeeded in reducing it to the metallic state), to exist in combination with iron and manganese, in the mineral *wolfram* (tungstate of iron and manganese), which is found in Cornwall, Germany, and elsewhere. The best way, however, of procuring this metal is that of Allen & Aikin, namely, by subjecting tungstate of ammonia to an intense heat. The oxide may be reduced with the assistance of charcoal.

The principal form in which tungsten occurs in nature is that of tungstie acid; it is found in an uncombined state, but it is usually met with in connection with tin-stone. Perhaps, the best way of obtaining the tungsten is to knead a mixture of tungstic acid and charcoal into a paste with

oil, and subject the mass in a carbon crucible to the heat of a blast furnace.

The Rev. F. Lunn, M.A., F.R.S., in his valuable work on "Chemistry," which forms the 32nd part of the "Encyclopædia Metropolitana," states that this metal, from its extreme infusibility, has only been seen in a mass of small agglutinated grains of a greyish-white colour and some brilliancy; and that it is so hard as scarcely to be affected by the file.

Tungsten has a specific gravity of 17·6 (according to Don d'Elhuyarts), and is believed to be a good conductor of heat and electricity, brittle, and uninfluenced by the magnet. It unites with oxygen in two definite proportions forming *binoxide of tungsten*, and *teroxide* or *tungstic acid:* the former of these, called also *tungstous acid* may be obtained by passing hydrogen over tungstic acid at a low temperature; it is a dark copper-coloured powder, approaching to black, which, when heated in contact with the air, takes fire, burns like tinder, and is converted into tungstic acid. It contains 16·6 per cent. of oxygen.

The *teroxide* or *tungstic acid* may be procured by boiling wolfram in muriatic acid, decanting off the acid, and allowing it to settle. A yellow powder gradually precipitates, which must be dissolved in ammonia, the solution evaporated to dryness, and the residue subjected to a red heat. This yellow oxide consists of 80 parts tungsten + 20 parts oxygen.

Tungsten till recently has been looked upon only as a mineralogical curiosity, but it has lately been combined with iron, and the alloy found to possess the properties of the best steel; it forms alloys with several of the other metals, none of which, however, have been applied to any useful purpose.

CHAPTER LIV.

URANIUM.

Uranium was discovered in 1789, by Klaproth, while examining a mineral called *pech-blende*, which he procured from Joachunstahal, in Bohemia; it received its name from

having been first extracted from its ore just about the same time that Herschel discovered his new planet Uranus. It is also met with in a state of oxide in the *green mica*, or *uranglimmer*, and in the *uranochre*.

If the ores of uranium be dissolved in nitric or nitro-muriatic acid, and a caustic alkali added to the solution, the oxide will be precipitated. If this oxide be mixed with one-twentieth of charcoal powder, and exposed to an intense heat, it will be reduced: it requires a much greater heat than our furnaces can afford for its perfect fusion.

Uranium is a hard, brittle metal of an iron-grey colour, considerable lustre, and a specific gravity of 9·0. It has hitherto been obtained only in small quantities; its properties, therefore, are but imperfectly known. When exposed to a red heat it undergoes a species of combustion, and a greyish-black powder is obtained, which is the *protoxide*, and consists of 95 uranium + 5 oxygen. Uranium, when heated in a pulvurent state to 402 degs. Fahrenheit, burns with great splendour. If this metal be dissolved in nitric acid, and potash added to the solution, the *peroxide* will be precipitated, which is a yellow tasteless powder, insoluble in water, and consisting of 80 metal + 20 oxygen. Various opinions, however, are entertained by several celebrated mineralogists as regards the constitution of the oxides of this metal.

Uranium fuses with great difficulty, and is not tarnished by exposure to the atmosphere at its ordinary temperatures.

It occurs in combination with oxygen and a few other ingredients in *uran-ochre*, which is found in Saxony, and in Tin Croft mine, Cornwall, accompanying *uranite*, which is a *phosphate of uranium*, and occurs crystallized in the form of a square prism, which may easily be divided into thin laminæ. Uranite is found at Autun, in Burgundy, of a rich lemon-colour, and sometimes of a delicately pale yellowish-green colour, but specimens showing these colours are rare. The finest, and, at the same time, the most common varieties occur in Cornwall; these have a splendid green colour. The uranite may sometimes be seen in these specimens, coating dark brown-coloured quartz, with brilliant drusy crystallizations, often in distinct crystals, amongst yellowish-brown iron-ore.

CHAPTER LV.

VANADIUM.

THIS rare metal was discovered in 1801, by Del Rio, and was named *vanadium*, by Sefström, in 1830, from *vanadis*, a cognomen of the Scandinavian goddess Freia. Sefström obtained it from the iron of Taberg, in Sweden, and from the slag of the ore. It has since been met with by Professor Johnston, in a new mineral occurring at Wanlock Head, which he found to be *vanadiate of lead:* this ore is likewise found at Zimapan, in Mexico, and has recently been met with in Chili. This metal also exists in nearly all clays, although in extremely minute quantities.

Vanadium may be obtained by reducing vanadic anhydride with potassium, and digesting the product in water; a brilliant metallic powder will be obtained, soluble in aqua regia, but unacted upon by boiling nitric, sulphuric, or hydrochloric acids.

This metal resembles chromium in some of its properties, it has a steel-white lustre, is extremely brittle, infusible, and not acted upon by either air or water at common temperatures.

Oxygen and vanadium unite in three proportions. The first, the *protoxide*, which has the appearance of graphite, may be procured by passing hydrogen over heated vanadic acid. *Binoxide of vanadium*, or *vanadic oxide*, generally called *vanadous acid*, is a black powder, and may be procured by heating the protoxide in contact with the air. It unites with acids to form salts, which possess a blue colour. The *teroxide*, or *vanadic anhydride*, usually called *vanadic acid*, is a powerful, brownish-red metallic acid, which remains in the form of powder on heating bivanadiate of ammonia. It fuses at a red heat, without further change, and crystallizes on cooling, becoming incandescent from the evolution of latent heat in the act of solidification.

CHAPTER LVI.

YTTRIUM.

This metal, the compounds of which taste sweet like those of glucinium, was discovered by M. Wöhler, in 1828; and received its name from Ytterby, in Roslagen, Sweden, where the mineral from which it is obtained, at first called *ytterbite*, but afterwards *gadolinite*, was first found by Professor Gadolin.

Yttrium may be procured by heating a stratified mixture of chloride of yttrium and potassium in a crucible made of platinum: after the chloride of potassium has been removed by water, the yttrium will remain in dark, iron-grey, shining pulvurent scales.

This metal is capable of receiving a high metallic lustre under the burnisher; it is not oxidized by steam or a red heat in the air; but, when sufficiently heated in oxygen, it burns with splendid scintillations, and yields a white *protoxide*, called *yttria*, which is white, tasteless, insoluble in water, and has a specific gravity of 4·842.

CHAPTER LVII.

ZINC.

Zinc, in the metallic state, was unknown to the ancients, although they seem to have been acquainted with the ore; this, no doubt, was owing to its volatile nature and strong affinity for oxygen: but the oxide, under the name of *cadmia*, appears to have been largely used in some of their medicinal preparations, and in the formation of brass. Pliny writes, *Plura autem genera sunt, namque ipse lapis ex quo æs, cadmia vocatur.*

Paracelsus Theophrastus appears to be the first author who makes use of the name zinc; it is said that he discovered the metal in 1530.

Zinc has never yet been found in the metallic state, but it exists abundantly in combination with sulphur, as *sulphide of zinc;* in the more valuable form of *carbonate of zinc*, or *calamine* [both of which ores (*i.e.* this and the preceding) we will notice shortly]; and sometimes combined with oxygen and silica.

This is a bluish white metal, somewhat brighter than lead, but not quite so bright as tin. It possesses a crystalline structure, and at ordinary temperatures it is very brittle: when broken, by bending, its texture seems to be composed of cubical grains. When cold, it cracks when flattened by the hammer; but between 250 & 300 degs. it is malleable, capable of being forged, laminated, and even of being rolled out into thin plates, and drawn into wire. Its tenacity is such that a wire 0·78 inch in diameter will support 109·8lb. When heated to about 680 degs. Fahrenheit it fuses, and if cooled slowly, crystallizes in quadrangular prisms. The surface of zinc, when exposed to the air, soon becomes tarnished, but the tarnish preserves the metal from any further change. If exposed to a bright-red heat, the metal ignites, burns with great brilliancy, being converted into a white oxide, which flies off in fine flakes resembling cotton; hence it received the name of *flowers of zinc:* the alchemists gave to it the name of *philosopher's wool:—lana philosophica, nihil album.*

Zinc is readily acted upon by acids and alkalies, either in the metallic state, or when oxidized.

Oxygen and zinc unite in only one proportion, which is the *white oxide* obtained by burning the metal in the air. It may also be procured by heating the carbonate till the carbonic acid is expelled; and by dissolving zinc in sulphuric acid and precipitating by means of potash. It consists of 80·39 zinc + 19·61 oxygen. It is very white and light; it closely resembles magnesia in appearance and properties; it is insoluble in water, and consequently tasteless, and is not altered by exposure to the air.

The salts of zinc are colourless, and those which are soluble in water have a disagreeable metallic taste, and act as emetics. The carbonate and the sulphate are the two principal salts of this metal.

Carbonate of zinc is found native as calamine. *Calamine*, or *lapis calaminaris*, occurs both in masses and in a crystal-

lized state, usually in combination with a large portion of silica; it is a *native oxide* of zinc combined with carbonic acid: the Derbyshire ore consists of 34·8 oxide of zinc + 65·2 carbonic acid. In colour it is either white, grey, or brown, and it dissolves with effervescence in acids. It may be reduced by mixing it with coke or charcoal, and exposing it to a red heat in peculiarly constructed crucibles. By this means, the carbonic acid is expelled from the ore by the high temperature, and the charcoal (or coke) removes the oxygen of the metallic oxide, forming carbonic oxide: the zinc rises in vapour, and, distilling over, is received in water.

Sulphate of zinc, or *white vitriol*, is generally formed in Germany from the ore called *blende*, which is a sulphuret of zinc. By the agency of fire, and the access of atmospheric air, the sulphur is converted into sulphuric acid, and by means of proper evaporation and cooling, the salt is procured in a crystallized state. It greatly resembles Epsom salts: it has an astringent metallic taste, and is employed in medicine as an emetic.

Sulphide of zinc, *blende*, or *Black Jack*, is frequently met with in nature, as an ore of zinc; it generally occurs crystallized in tetrahedrons or modifications of the form; its colours vary from reddish brown to black, but it is sometimes found of a greenish yellow tint. It is obtained principally from Cornwall, Derbyshire, and Cumberland, in England; from Saxony, Hungary, and Transylvania. Zinc-blende is first roasted (*i.e.*, heated in a current of air), to rid it of the sulphur; it is thereby converted into an oxide, which is then treated as calamine stone.

The *chloride of zinc* is obtained by burning the metal in chlorine; it is a solid substance of a whitish grey colour and semi-transparent. This, which is the only known chloride of zinc, has been called *butter of zinc*, and *muriate of zinc*, and consists (according to Dr. John Davy) of nearly equal weights of zinc and chlorine.

Zinc, being tolerably abundant, so very slowly acted upon by the air, and cheaper than lead or tin, is frequently substituted for lead in roofing houses, and instead of tin plate for the construction of milk pails and similar vessels. It is very often used for coating iron to preserve it from rust and is employed for gutters, chimney-tops, &c. Iron, which is to be coated with zinc is first thoroughly cleansed

by dilute sulphuric acid; it is afterwards passed through troughs of melted zinc; it is called *galvanized iron*, though no galvanic process is employed in its preparation.

It is also largely used in the manufacture of galvanic batteries; and, mixed with copper, as the important alloy *brass*, it is extensively employed in the arts.

Its carbonate or oxide may be advantageously substituted for white lead in house-painting, as it neither injures the health of the workmen, nor tarnishes by exposure to the air.

Zinc is also used for printing drawings by the art called Zincography.

This metal enters into union with phosphorus, sulphur, selenium, iodine, and most of the metals.

CHAPTER LVIII.

ZIRCONIUM.

This is a rare metal occurring in the minerals *jargon* and *hyacinth*, which contain the oxide in combination with silicic acid; it is said to have been discovered by Berzelius in 1824. It may be obtained by heating the double fluoride of zirconium and potassium, with potassium, and separating the salt with cold water.

Zirconium is a perfectly black powder, which acquires only a very feeble lustre when burnished; when heated in air or oxygen, it takes fire and burns with a very intense flame producing zirconia. *Zirconia* is a hard whitish powder, destitute of taste or smell, insoluble in water, and more fusible than any of the other earths.

This metal does not oxidize in water or in muriatic acid, but it may be dissolved in nitro-muriatic and fluoric acids; in the last, with the disengagement of hydrogen.

Zircon, is a crystalline mineral, transparent to sub-translucent, of various colours, adamantine lustre, and consisting of 33·3 silica, and 66·7 zirconia; it comprises three varieties:—*hyacinth*, *jargon*, and *zirconite*. It is found at Expailly in France, at Freidrichsuarn, Norway, Greenland, Ceylon, and in the United States.

CHAPTER LIX.

CONCLUDING REMARKS

ON THE CLASSIFICATION OF THE METALS.

"Nature! great parent! whose unceasing hand
Rolls round the seasons of the changeful year;
How mighty, how majestic are thy works!
With what a pleasing dread they swell the soul
That sees astonish'd! and astonish'd sings."—THOMSON.

HAVING now given a description of each metal alphabetically, let us now proceed to say something about their *classification;* but before we do so, we will make three quotations from modern writers. The first says, "It has been said of man that he is born to consume the fruits of the earth; with equal justice it might be remarked, that he is born to consume its minerals and metals, for not a step can he advance beyond the rudest form of existence without their presence and assistance. He might endure as the South Sea Islander, the North American Indian, or the still more degraded Esquimaux; he might hunt, or fish, or pluck the fruits of the palm-grove; he might build a hut, cook his food, or even weave for himself a rude garment; but this would be the limit of his perfection till he became acquainted with the metals, learned to fashion his implements of them, began to construct machinery, and generally to enter upon that condition of life which separates the savage from the civilized. The history of our own island furnishes by far the most striking illustration of this doctrine.

Without our mines of iron, copper, tin, lead, &c., and without our abundant stores of coal to smelt and prepare them, where would have been our substantial homes, fitted with every comfort and elegance?—where those implements by which the soil is tilled and cultivated?—where, in fine, the countless applications of machinery by which we are borne with rapidity over the land and across the ocean, by which knowledge is increased and disseminated, by which all that administers to our convenience and refinement is produced, and by which the sum of human toil is abridged, and our countrymen as a nation raised from the condition of a mere animal to that of a humanized existence."

Another remarks:—"Our very bodies are built of metal. The crimson flood which rushes through our veins is coloured by *iron;* our flesh and bones are made of lime, potash, and soda—(the oxides of *calcium*, *potassium*, and *sodium*)—all of which are brilliant silvery metals. Common table-salt—chloride of sodium—contains 40 per cent. of *sodium*. Bricks are silicate of *aluminium;* stone and mortar are the *oxide of calcium*, or *lime*."

"Suppose," says a third, in alluding to the great value of the metals, "we were deprived of iron alone: what misery, what confusion would result, and to what primeval barbarism should we be again plunged; no ploughshares to cultivate the ground; no swords to repel our foes; no vast machinery to abridge our labours, and multiply our riches; no compass to direct the mariner across the deep; half the genius, the wisdom, and the intellect, imparted by the Almighty to mankind, would have no scope for its exercise, and we should be little removed from those primitive savages, who lived upon acorns and wild berries. Without iron, we could not have existed for it enters into the composition of our blood."

The *classification* of the metals is usually based upon their relative affinities for oxygen. They may be grouped as follows:—

Class I.—Those which absorb oxygen at the common temperatures of the atmosphere; whose oxides are not decomposed by any attainable heat, and only with difficulty by bringing bodies, which have strong affinities for oxygen, in contact with them. Such are the following:—

Potassium	Barium
Sodium	Strontium
Lithium	Calcium

Class II absorb oxygen at a rather elevated temperature, and their oxides are quite as difficult of reduction, as those of the above. Water is decomposed by them, at temperatures varying from 200 to 400 degs., and some of them only at a red heat.

Glucinium	Lanthanium
Aluminium	Didymium
Magnesium	Manganese
Zirconium	Uranium
Thorinum	Pelopium
Yttrium	Niobium
Cerium	Erbium
	Terbium.

Class III.—The metals belonging to this class absorb oxygen only at very high temperatures; their oxides are reducible by heat, but easily decomposed by hydrogen, carbon, and carbonic oxide; and they decompose water only at a red heat, or by the aid of acids.

Iron		Zinc
Nickel		Cadmium
Cobalt		Chromium
	Vanadium.	

Class IV.—These decompose water at a red heat, but only under the influence of acids, or strong bases, such as potash.

Tungsten		Titanium
Molybdenum		Tin
Osmium		Antimony
	Tantalium.	

Class V.—The oxides of these metals cannot be decomposed by heat. The metals gradually decompose aqueous vapour at a very elevated temperature.

Bismuth
Lead
Copper.

Class VI.—The metals which do not decompose water, under any circumstances, but whose oxides are reducible by heat.

Mercury		Palladium
Silver		Ruthenium
Rhodium		Platinum
Gold		Iridium.

Some mineralogists classify the metals according to the nature of their oxides. They group them in four classes:—

Class I.—Alkaline Metals.

Potassium
Sodium
Lithium.

Class II.—The Alkaline-Earthy.

Calcium
Barium
Strontium.

Class III.—The Earthy.

Aluminium		Zirconium
Magnesium		Yttrium
Glucinium		Erbium
Thorinum		Cerium
Pelopium		Lanthanium
Niobium.		Didymium
	Terbium.	

Class IV.—Metals Proper:—All the remaining metals.

The metals are mostly found in the bowels of the earth, in what are called *veins* (from the Latin, *vena*), excepting iron, which occurs in strata. A vein is a fissure or rent, filled with mineral or metallic matter, differing from the rock in which it occurs. The word *strata*, the plural of *stratum* (from the Latin, *sterno*, I spread), is applied to layers in which the rocks lie one above another. The metals are obtained by penetrating from the surface of the earth to the vein, and there following it in whatever direction it may lie. The hollow places thus formed are called *mines*, and the men employed in them are denominated *miners*. If the veins be at a great depth, or, if they extend to any considerable distance beneath the surface of the earth, it becomes necessary, at intervals, to make openings, or *shafts*, to the surface, in order that fresh air may be admitted and circulated, and that the water, which collects at the bottom, may be carried off by means of drains, pumps, or steam engines, as the situation or circumstances may require or allow. *Metalliferous* veins (those bearing or yielding metals: from the Latin, *metallum*, a metal, and *fero*, I bear) extend irregularly to unknown depths, and they vary in width from an inch to twenty feet. The composition of these veins or *lodes* (from the Saxon, *lædan*, to lead) are as valuable as the rocks through which they pass. Lime-stone is the most metalliferous of the secondary rocks, and lead and copper are the metals usually found in it.

As the metals occur in every part of the world, it is evident that their distribution does not, like that of animals and vegetables, depend upon the climate; it is remarkable that those which are the most useful to man are the most abundant, and the most widely-distributed; and it may also be worthy of notice that those portions of the earth which are found to be unfit for the support of animal and vegetable life are generally rich in their mineral treasures.

"These are Thy glorious works, Parent of Good,
Almighty: Thine this universal frame,
Thus wond'rous fair; Thyself how wond'rous then,
Unspeakable! who sitt'st above the heavens,
To us invisible, or dimly seen
In these, Thy lowest works. Yet these declare
Thy goodness beyond thought, and power divine."

MILTON.

Before we conclude, however, we must state that notwithstanding the *origin* and *growth* of metals in the bowels of the earth form very attractive subjects for examination, nothing satisfactory upon either of them has been attained. Descartes asserts that the metals were created at the same time as the earth; that they were ranged by the laws of gravity, about the centre; and that they were subsequently corroded by acid salts, and carried with them by subterranean heat to various parts of the globe. Although various opinions have been expressed upon these matters, that of Descartes appears to be regarded by many as the best grounded, and most in accordance with the rules of nature. Still, let us not forget the words of the poet Yalden (the intimate friend of Bishop Atterbury), who says:—

"Through dark retreats pursue the winding ore,
Search Nature's depths, and view her boundless store;
The secret cause in tuneful numbers sing,
How Metals first were formed, and whence they spring;
Whether the active sun, with chymic flames,
Through porous earth transmits his genial beams,
With heat impregnating the womb of night,
The offspring shines with its paternal light;
Or whether, urged by subterraneous flames,
The earth ferments, and flows in liquid streams;
Purged from their dross, the nobler parts refine,
Receive new forms, and with fresh beauties shine;
Or whether by creation first they sprung,
When yet unpoised the world's great fabric hung,
Metals the basis of the earth were made,
The bars on which its fixed foundation 's laid:
All second causes they disdain to own,
And from the Almighty's *fiat* sprung alone."

GLOSSARY

OF SOME OF THE MOST IMPORTANT TECHNICALITIES USED IN THE SCIENCE.

*N.B.—An explanation of many other terms may be found in the body of the work, upon reference to the index. The following abbreviations are employed in giving the derivations of the various terms:—*LAT., *for Latin;* GK., *for Greek;* ARAB., *for Arabian; and* FR., *for French.*

ABSORB (Lat. *absorbeo*, I drink in or suck up). To imbibe; to drink in; to suck up, like a sponge.

Potassium is kept under naphtha, on account of the rapidity with which it *absorbs*, or sucks up, oxygen from the atmosphere.

ACETATE (Lat. *acetum*, vinegar). A compound of acetic acid with a base.

Acetate of lead is prepared by dissolving litharge in *acetic acid.*

ACETIC (Lat. *acetum*, vinegar). Belonging to vinegar.

In fact, the name by which acetic acid is more popularly known is *vinegar;* distilled acetic acid forming distilled or colourless vinegar.

ACID (Lat. *aceo*, I am sour). A term applied to all bodies which, combining with bases, form salts.

Most of these substances produce that sensation on the tongue which we call *sour.*

AFFINITY (Lat. *affinis*, near to, or bordering upon). The tendency or disposition which some substances possess to unite so as to form a new substance.

Calcium is said to possess a great *affinity* for oxygen, because, as we have already stated, as soon as atmospheric air is admitted to it, it absorbs oxygen, and, burning with an intense white light, is very soon converted into lime, the protoxide of calcium.

AGENT (Lat. *ago*, I act). When a substance possesses the property of producing chemical *action*, it is termed a chemical *agent*.

The mercury may be driven from an amalgam by the *agency* of heat. Again, aqua regia, a mixture of nitric and hydrochloric acids, is what is generally employed in dissolving gold. Now, in these two examples, heat and aqua regia are said to be chemical *agents*.

ALCHEMY (Arab. *al*, the; *kimmia*, secret; or according to some, Gk. *cheo*, I pour). The pretended science of converting other metals into gold, &c.

The alchemists endeavoured, and in several instances succeeded, in making short-sighted people believe that they were acquainted with this *secret*, which they called *alchemy*.

ALLOY (Lat. *ad*, to; *ligo*, I bind). A compound of any two or more metals.

Bell-metal is an *alloy*; because it consists of copper and tin bound together (*i.e.*, in a state of combination).

We have devoted a separate chapter to alloys.

ALLUVIAL (Lat. *alluvies*, a muddy stream). Produced by the deposit of mud, &c.; washed down by torrents of water.

Gold has been found in the *alluvial* deposits of the Rhone, the Rhine, and the Danube.

AMALGAM (Gk. *malaso*, I soften). This word has been applied to any combination of mercury with any other metal.

Mercury possesses the property of *softening* (or as mineralogists term it, *rendering more malleable*) the metals with which it unites.

ANALYSIS (Gk. *ana*, back; *luo*, I loosen). This word denotes that series of operations by which the component parts of bodies are determined, whether they be merely separated, or exhibited apart from each other; or whether their distinctive properties be shown by causing them to enter into new combinations.

ANTIDOTE (Gk. *anti*, against; *didomi*, I give). Anything which acts as a remedy in counteracting poisons or anything noxious.

If a person has swallowed a powerful acid, chalk will destroy the potency of the acid, if given immediately. The term *antidote* may therefore be applied to chalk.

ASTRINGENT (Lat. *ad*, to; *stringo*, I bind or tie fast). Binding or contracting.

Metallic salts are said to be *astringent*, when they produce the opposite effect of purgatives.

ATMOSPHERE (Gk. *atmos*, vapour; *sphaira*, a globe or ball). The mass of air which surrounds the earth, an animal, or any other body,—such, for instance, as a metal.

Some metals, without the influence of heat, very readily absorb oxygen from the *atmosphere* (or that *body of vapour* which surrounds them), and are converted into oxides.

ATTRACTION (Lat. *ad*, to; *traho*, I draw). The tendency of bodies to unite or cohere.

Metals which are readily converted into oxide are said to possess a great *attraction* for oxygen.

BAROMETER (Gk. *baros*, weight; *metron*, a measure). An instrument which *measures* the *weight* of the atmosphere, and shows the variation of its pressure, by the rise or fall of a column of mercury in a glass tube attached to a graduated plate.

BASE (Gk. *basis*, a foundation). This chemical term is generally used to denote the metal, earth, or alkali, which is combined with an acid to form a salt.

BLOW-PIPE. This is an instrument by which a current of air is driven on the flame of a candle, thereby producing an increased heat.

It is of great service in the analysis of minerals, oxides, &c.; and for other chemical purposes.

CALCINE (Lat. *calx*, lime). To drive off moisture, or any other volatile matter, by the application of heat, from saline, metallic, and other substances, so as to render them friable, as in the operation of *lime-burning*.

CARBON. This word is applied by chemists to the base of common charcoal, divested of all impurities.

The most striking property of pure carbon is that it is capable of crystallization (though not by art); and in this state it is called *diamond*. It has been proved by Sir Humphrey Davy and others that the diamond consists *solely* of carbon, being, in fact, crystalline charcoal.*

CARBONATE (Lat. *carbo*, a coal). A salt produced by the union of carbonic acid with a base. Examples:—

Carbonate of baryta consists of 78 baryta and 22 carbonic acid.
Carbonate of strontia consists of 70 strontia and 30 carbonic acid.
Carbonate of lime (as found in nature) consists of 56 lime and 44 carbonic acid.

CARBURET (Carbon). A carburet is a compound of carbon with hydrogen or a metal.

Plumbago, which consists of carbon and iron, is called *carburet of iron*.

CHARCOAL. Charcoal is obtained by burning wood in close vessels. It is an oxide of carbon and usually contains a small portion of salts and earth.

This substance is applied to so many purposes by the chemist and manufacturer, that it would require more space than we could well spare, to enumerate them.

CHEMISTRY (Gk. *cheo*, I pour). The science which investigates the nature and properties of all materials which enter into the composition of the earth, sea, and air, and of the beings which inhabit them.

It has also been defined as the art whereby sensible and natural bodies are so changed chiefly by the agency of fire, so as to enable us to discover their several and peculiar powers and properties, either in a simple or compound state.

CHLORIDE (Chlorine). A substance formed by the union of chlorine with a metal.

Common table salt (muriate of soda), when reduced to dryness, is a *chloride of sodium*,

CHLORINE (Gk. *chloros*, yellow-green) is an elementary gas, so named from its peculiar colour.

This term was assigned by Sir H. Davy to this gas, which, after resisting the most powerful means of decomposition which his sagacity could invent or his ingenuity could apply, he declared to be, according to the true logic of chemistry, an elementary body, and not—what it had previously been considered as—a compound of muriatic acid and oxygen.

* For a description of this very highly prized jewel, see article, entitled "Notes on the Diamond," by the author of this work, in "Recreative Science," 3 vols., fcap. 4to., cloth gilt, £1 2s. 6d., or in handsome library binding, £1 4s.; illustrated with more than one thousand engravings, and published by Groombridge and Sons, Paternoster Row, London.

COMBINATION (Lat. *con*, with; *bini*, two and two). The union of two or more substances into a new compound.

For instance, an *alloy* is a combination with two or more metals (except mercury); again, an *oxide* is a combination of a metal and oxygen.

COMBUSTION (Lat. *comburo*, I burn up). The act of absorption of combustible substances from atmospheric or vital air.

The product of combustion is generally an *oxide*, or an *acid*, or both; but when potassium or sodium are ignited, an *alkali* is produced.

CRUCIBLE (Lat. *crucio*, I torment). A vessel made of clay, sand, and ground ware, or any other material capable of enduring heat, in the form of an inverted cone, which is of indispensable use in chemistry.

CRYSTALLIZATION (Gk. *krustallos*, ice or crystal). An operation in nature in which various earths, salts, and metallic substances, passing from a fluid to a solid state, assume certain crystalline or geometrical forms.

Pure carbon (as we have before stated) is capable of *crystallization*, though not by art, in which state it is called diamond.

CUPEL (Lat. *cupella*, a little cup). A vessel made of calcined bones, mixed with a small proportion of clay and water, which, when heated, absorbs the refuse matter of the metals placed in it for purification.

It is used whenever gold and silver are refined by mixing them with lead; the process is termed *cupellation*.

DETONATION (Lat. *de*, from; *tono*, I thunder). An explosion, or sudden report.

This word is commonly applied to the explosion which takes place when nitre is thrown upon burning charcoal.

DIGESTION (Lat. *di*, apart; *gero*, I bear or carry). The effect produced by the continued soaking of a solid in a liquid with the application of heat.

Thus, we frequently speak about *digesting* a metal in an acid.

DISTILLATION (Lat. *dis*, apart; *stilla*, a drop). A process by which the volatile parts of a substance are separated from the more fixed, that both may be preserved in a state of separation.

Distilled acetic acid (or colourless vinegar) is that which has been freed from all impurities by this process.

EVAPORATION (Lat. *e*, from; *vapor*, vapour). The convertion of fluids into vapour by heat.

When we speak of *evaporating* a precipitate to dryness, we mean, applying sufficient heat as will dispel the acid or moisture.

FULMINATE (Lat. *fulmen*, thunder). To detonate or explode.

Fulminating powders are those which when rubbed or smartly struck with a hammer, afford an explosion.

FUSION (Lat. *fundo*, I pour out). The rendering of a metal, or any other body naturally solid, fluid by the artificial application of heat.

GRANULAR (Lat. *granum*, a grain). Consisting of or resembling grains.

Hence we say that a certain metal has a *granular*, or laminar, or lamellar texture as the case may be.

HEAT. The sensation produced by the contact of a hot substance or body of air.

HYDRATE (Gk. *hudor*, water). A compound in which water exists in chemical combination.

Example:—Common slacked lime. which is properly a *hydrate* of lime.

HYDROGEN (Gk. *hudor*, water). A colourless combustible gas, the lightest of elementary bodies; with oxygen it forms water.

Water consists of ·8888 parts (by weight) of oxygen, and ·1112 parts of hydrogen.

LAMINAR, LAMINATED (Lat. *lamina*, a plate). Arranged in plates or scales.

Zinc, when cold, is *laminated*.

LAMELLAR (Lat. *lamella*, a little plate). Arranged in *thin* scales or plates.

METALLURGY (Gk. *metallon*, a metal; *ergon*, work). The art of working metals; more particularly of separating them from their ores.

MINERAL (Mine). Any substance, destitute of organization, occurring naturally at or below the surface of the earth.

It may have either a metallic, earthy, or saline nature, or it may be either simple or compound.

MINERALOGY (Mineral; Gk. *logos*, a description). The science which treats of the relations and properties of simple mineral substances.

REVERBERATORY (Lat. *re*, back; *verbero*, I beat). A term applied to a furnace, in which the crucible or other object is heated by a flame of hot air, which is *reverberated*, or driven back, from the roof.

ROASTING. A preparative operation in metallurgy, in which the sulphur, arsenic, &c., with which a metal may be combined, are dissipated.

We have frequently spoken of *roasting an ore* of different metals.

SALT (Lat. *sal*, common salt). This term is applied to any substance resulting from the combination of two oxides or analogous substances, one of which is highly acid, while the other is highly basic.

Under this name are classed all the sulphates, muriates, nitrates, chlorates, carbonates, phosphates, sulphites, phosphites, fluates, borates, arseniates, tungstates, acetates, oxalates, tartrates, citrates, camphorates, suberates, prussiates, &c.

SMELTING. The operation of fusing ores for the purpose of obtaining the metals, which they contain free from sulphur, arsenic, &c., with which they be may mineralized.

SOLUTION (Lat. *solvo*, I melt). The perfect union of solid substance with a fluid.

Example:—Nitrate of silver dissolved in distilled water.

TEMPERATURE (Lat. *tempero*, I mix, or moderate). The state of a body with regard to heat and cold, especially as compared with some other body.

Mercury is fluid (we have said) at the ordinary *temperatures* of the atmosphere.

THERMOMETER (Gk. *therme*, heat; *metron*, a measure). An instrument for measuring the heat or temperatures of bodies, by the regular expansion of mercury in a glass tube.

The thermometers usually employed are Fahrenheit's, the Centigrade, and Reaumur's. The space betweeen the freezing and boiling points of water, in Fahrenheit's thermometer is divided into 180 degrees, the freezing point being marked at 32 degs., and the boiling point at 212 degs. The space in the Centigrade thermometer is divided into 100 degrees, and in Reaumur's into 80 degrees. Hence 5 degrees of the Centigrade or 4 of Reaumur's thermometer, are equal to 9 of Fahrenheit.

TRITURATE (Lat. *tritura*, a threshing or grinding). To rub or grind into a very fine powder.

Hence we speak of *triturating* (pulverizing, or reducing to powder) a mineral, &c., in a mortar.

VOLATILITY [Volatile (from Lat. *volo*, I fly)]. The property which disposes metals to assume the gaseous state.

Example of a *volatile* metal:—Arsenic.

ZERO (Italian, nothing). The point of a thermometer from which it is graduated.

In the Centigrade and in Reaumur's it is the freezing point of water; in Fahrenheit's, 32 degrees below freezing point.

INDEX

(TO BODY OF WORK, ONLY).

Acetate of Lead, 64.
Acid of Molybdena, 75.
Aërolites, 40.
Æs, 41.
Ague-drops, 24.
Alchohol, 22.
Alloys, 12.
Alum, 14.
Aluminium, 14, 111.
Amalgam, 12, 74.
Anatase, 101.
Animal Bone, 36.
Antimonial Wine, 21.
Antimonious Acid, 20.
Antimony, 18.
Antimony-ochre, 18.
Apatite, 36.
Aqua Regia, 50.
Arable Soils. 15.
Arcet's Fusible Metal, 30.
Argentane, 45, 77.
Argentiferous Ores, 90.
Argentine Flowers of Antimony, 20.
Argentum Vivium, 72.
Argillaceous Earths, 15.
Arsenic, 22.
Arsenic Acid, 24, 25.
Arsenical Pyrites, 23.
Arsenicon, 25.
Arsenious Acid, 24.
Arsenite of Copper, 26.
Arsenite of Lead, 26.
Arsenite of Potash, 26.
Arsenite of Soda, 26.
Arseniates, 26.
Arsenites, 26.
Arsenuretted Hydrogen Gas, 25.
Artificial Alloys, 12.
Aurum Paradoxicum, or
Aurum Problematicum, 95.
Aurum Mosaicum, or
Aurum Musivum, 100.
Azure Blue, 39.
Barium, 27.
Baroselenite, 28.
Baryta, or Barytes, 27.
Baryto-strontianite, 94.
Bell-metal, 14, 44.
Berylla, 47.
Beryllium, 46.
Binoxide, 11.
Bismuth, 29
Black Lead, 59.
Black Jack, 108.
Black Oxide of Cobalt, 39.
Black Oxide of Copper, 44.
Black Oxide of Iron, 57, 58, 60.
Black Oxide of Manganese, 70.
Black Oxide of Mercury, 73.
Black Oxide of Nickel, 77.
Black Oxide of Rhodium, 86.
Black Oxide of Titanium, 101.
Black Wadd, 70.
Blende, 108.
Block Tin, 98.
Blue Carbonate of Copper, 42.
Blue Oxide of Cobalt, 39.
Blue Oxide of Molybdenum, 76.
Brass, 44, 109.
Bricks, 15.
Bright Native Cinnabar, 72.
Britannia-metal, 22.
Bronze, 14, 44.
Brown Oxide of Cerium, 37.
Brown Oxide of Chromium, 38.
Brown Oxide of Manganese, 70.
Brown Oxide of Molybdenum, 75.
Brown Oxide of Platinum, 82.
Brown Oxide of Rhodium, 86.
Brown Oxide of Sodium, 92.

Butter of Antimony, 20.
Butter of Arsenic, 26.
Butter of Zinc, 108.
Cadmia, 106.
Cadmia Fossilis, 32.
Cadmium, 32.
Cæsium, 33.
Calamine, 107.
Calcareous Spar, 36.
Calcined Mercury, 73.
Calcium, 35, 111.
Calomel, 73, 74.
Carats of Gold, 52.
Carbonate of Zinc, 107.
Carburet, 12.
Carburet of Iron, 59.
Cast Iron. 59, 60.
Cauk, 28.
Centigrade Thermometer, 19.
Cerite, 62.
Cerium, 36.
Ceruse, 63, 64.
Chalk, 36.
Chloride of Antimony, 20.
Chloride of Arsenic, 25, 26.
Chloride of Magnesium, 88.
Chloride of Niobium, 78.
Chloride of Sodium, 88, 93.
Chloride of Zinc, 108.
Chromate of Iron, 38.
Chromate of Lead, 38.
Chromic Acid, 38.
Chromium, 37.
Cinnabar, 71, 72, 74.
Classification of Metals, 110.
Clay Iron Stone, 57.
Cobalt, 38.
Cold-short Iron, 60.
Colica Pictorum, 64.
Columbite, 40.
Columbium, 40.
Common Clay, 15.
Common Potash, 84.
Common Soda, 92, 93.
Contractibility, 9.
Copper, 41.
Copper Pyrites, 42, 44.
Corneous Mercury, 72.
Corundum, 15.
Corrosive Sublimate, 74.
Crucibles, 15.
Crude Antimony, 18.
Crude Platinum, 82, 86.
Crystallization, 6.
Cupellation, 49.
Dark-red Native Cinnabar, 72.
Dark-red Oxide of Iridium, 55.
Dates of Discoveries, 4, 5.
Deep blue Oxide of Iridium.
Dendritic Silver Ore, 90.
Derivation of Names, 4, 5.
Detonation, 19.
Deutoxide, 11.
Didym, or
Didymium, 46.
Dilatability, 9.
Diluting, 19.
Distil, 20.
Doebereiner's Lamps, 83.
Ductility, 9.
Dutch Metal, 43.
Dutch Gold, 43.
Earthenware, 15.
Eggs of Birds, 36.
Elasticity, 10.
Electricity, 10.
Electrum, 48.
Emetic Tartar, 21.
Epsom Salt, 69.
Equivalents, 4, 5.
Erbium, 46.
Ethiop's Mineral, 74.
Fahrenheit's Thermometer, 19.
Flake-white, 31.
Flowers of Bismuth, 30.
Flowers of Zinc, 107.
Fluor Spar, 36.
Freiberg Zinc Blende, 53,
Frozen Mercury, 73.
Fuller's Earth, 15.
Fulminating Gold, 50.
Fulminating Platinum, 83.
Fulminating Powder, 75.
Fusibility, 6.
Gadolinite, 96, 106.
Galena, 65.
Galvanized Iron, 109.
German Silver, 45, 77.
Glass of Lead, 64.
Glucina, or
Glucine, 47.
Glucinium, 46.

Gold, 47.
Gold-leaf, 51.
Grain Tin, 98.
Graphite, 59.
Green Oxide of Chromium, 38.
Green Oxide of Manganese, 70.
Green Oxide of Platinum, 82.
Green Mica, 104.
Grey Oxide of Antimony, 19.
Grey Oxide of Tin, 99.
Grey Oxide of Strontium, 94.
Growth of Metals, 114.
Gun-metal, 44.
Gunpowder, 85.
Gypsum, 36.
Hackfong, 45, 77.
Haematite, 57.
Heat, 10.
Heavy Clay Lands, 16.
Heavy Spar, 28.
Horne Ore, 72.
Horn Silver, 91.
Hot-short Iron, 60.
Hume's Permanent White, 28.
Hyacinth, 109.
Hydrargyrum, 74.
Hydrate of Copper, 44.
Ilmenium, 53.
Indelible Marking Ink, 91.
Indium, 53.
Iodine of Antimony, 20.
Iridium, 54.
Iron, 55, 111.
Iserine, 101.
James's Powder, 21.
Jargon, 109.
Jeweller's Gold, 52.
Kelp, 93.
Keyser's Pill, 74.
King of Metals, 48.
King's Yellow, 23.
Knives of the Esquimaux, 12.
Kupper-nickel, 76.
Laminated, 18.
Lana Philosophica, 107.
Lanthanium, 62.
Lapis Calaminaris, 107.
Lead, 62.
Lead Glancea, 65.
Lead Pipes, 66.
Leaf-copper, 43.
Leaf-gold, 51.
Lepidolite, 34.
Lime, 35.
Limestone, 36.
Litharge, 64.
Lithia, 68.
Lithium, 68.
Lodes, 113.
Luna Cornea, 91.
Magistery of Bismuth, 31.
Magnesia, 69.
Magnesium, 68, 88.
Magnetic Iron Ore, 57.
Magnetism, 10.
Malachite, 42.
Malleable Iron, 59.
Malleability, 9.
Manganese, 69.
Mannheim Gold, 45.
Marble, 36.
Mariner's Compass, 58.
Mars, 57.
Martial Æthiops, 58.
Massicot, 64.
Meerschaum, 69.
Menachanite, 101.
Mercurial Hepatic Ore, 72.
Mercury, 71.
Metallic Lustre, 6.
Metalliferous Veins, 113.
Metallography, 3.
Meteoric Iron, 12.
Meteoric Stones, 40.
Milled Lead, 66.
Mines, 113.
Minium, 64.
Molybdena, 75.
Molybdenum, 75.
Molybdic Acid, 76.
Molybdous Acid, 76.
Mortar, 36.
Mosaic Gold, 100.
Mountain Green, 42.
Muriate of Mercury, 73, 74.
Muriate of Zinc, 108.
Names of Eliminators, 4, 5.
Names of the Metals, 4, 5.
Native Amalgam, 12, 72.
Native Arsenic, 22.
Native Cinnabar, 72.
Native Copper, 41.

Native Mercury, 72.
Native Metals, 12.
Native Oxide of Zinc, 107.
Native Platinum, 81.
Native Sulphuret of Lead, 65.
Native Tellurium, 95.
Natural Alloys, 12.
Natural Carbonate of Baryta, 29.
Newton's Fusible Metal, 30.
Nickel, 76.
Nihil Album, 107.
Niobic Acid, 78.
Niobium, 78.
Nitrate of Bismuth, 31.
Nitrate of Potassa, 85.
Nitre, 85.
Norium, 78.
Nuggets, 49.
Olive Oxide of Cobalt, 30.
Opacity, 11.
Orchroita, 36.
Ore, 12.
Orichalcum, 44.
Origin of Metals, 114.
Ormolu, 45.
Orpiment, 23.
Orthite, 96.
Osmium, 79.
Oxide, 11.
Palladium, 80.
Pearl-white, 31.
Pech-blende, 103.
Pelopic Acid, 81.
Pelopium, 81.
Peroxide, 11.
Pewter, 21.
Philosopher's Wool, 107.
Phosphate of Uranium, 104.
Phosphuret, 12.
Pig Iron, 60.
Pigs (Lead), 65.
Pigs (Tin), 98.
Pinchbeck, 45.
Platina, or
Platinum, 81.
Plumbago, 59.
Plumber's Solder, 100.
Pollux, 34.
Ponderous Spar, 28.
Porcelain, 15.
Potash, or Potassa, 84, 85.
Potassium, 84, 111.
Potter's Wheel, 15.
Precious Stones, 15.
Precipitate, 20.
Precipitate per se, 73, 74.
Priming, 64.
Prince's Metal, or
Prince Rupert's Metal, 45.
Protoxide, 11.
Prussiate of Palladium, 80.
Pure Baryta, 28.
Pure Gold, 52.
Pure Iron, 59.
Pure Lime, 35.
Purple Oxide of Gold, 51, 52.
Purple Powder of Cassius, 51.
Putty-powder, 99.
Quicksilver, 71.
Raddle, 15.
Realgar, 23, 25.
Reaumur's Thermometer, 19.
Red Copper Ore, 44.
Red Lead, 64.
Red Lead Ore, 37, 38.
Red Oxide of Cerium, 37.
Red Oxide of Copper, 43.
Red Oxide of Iron, 57, 58, 59.
Red Oxide of Mercury, 73.
Red Oxide of Rhodium, 87.
Red Oxide of Titanium, 101.
Red Precipitate, 73, 74.
Red Schorl, 101.
Regulus of Antimony, 18.
Regulus of Venus, 21.
Rhodium, 86.
Rock Crystal, 101.
Rock Salt, 93.
Roman Vitriol, 45.
Rose's Alloy, 30.
Rubidium, 87.
Ruby, 15.
Ruby Copper Ore, 42.
Rust, 58.
Ruthenium, 88.
Rutile, 101.
Saffron of Mars, 59.
Salifiable, 20.
Saltpetre, 85.
Sandarache, 25.

Sapphire, 15.
Saturn, 63.
Scheelium, 102.
Shafts, 113.
Sheet Lead, 66.
Shells of Fish, 36.
Shekels of Silver, 89.
Siderium, 88.
Silicon, 14.
Silver, 89.
Silver-leaf, 90.
Silver Wire, 90.
Similor, 45.
Slaked Lime, 36.
Smalt, 39.
Sodium, 92, 111.
Soft Iron, 59, 60.
Solder, 30.
Sows (Lead), 65.
Specific Gravities, 4, 5.
Speculum Metal, 45.
Sphene, 101.
Spongy Platinum, 83.
Standard Gold, 52.
Standard Silver, 91.
Steel, 60.
Sterling Gold, 52.
Stibiund, 18.
Strata, 113.
Stream-tin, 98.
Striated, 19.
Strontia, or
Strontian, 93, 94.
Strontianite, 94.
Strontium, 93.
Suboxide of Copper, 42, 43.
Sugar of Lead, 64.
Sulphate of Baryta, 28.
Sulphate of Lime, 36.
Sulphate of Magnesium, 69.
Sulphate of Zinc, 108.
Sulphide of Zinc, 107, 108.
Sulphuret, 12.
Sulphuret of Copper, 44.
Sulphuret of Molybdenum, 75.
Sulphuret of Mercury, 71.
Sulphurets of Arsenic, 23.
Supersulphuret of Copper, 44.
Symbols, 4, 5.
Sympathetic Ink, 39.
Tantalite, 40, 81.
Taste, 11.
Tantalium, or
Tantalum, 40.
Tartrate, 21.
Telluric Acid, 95.
Tellurium, 95.
Tellurous Acid, 95.
Tempering of Steel, 60
Tenacity, 9.
Terbium, 96
Teroxide, 11.
Terra Ponderosa, 28.
Thallium, 96.
Thermometer, 19.
Thorina, 97.
Thorinum, 96.
Thorite, 97.
Thorium, 96.
Tin, 97.
Tin-foil, 99.
Tin-plate, 100.
Tin-putty, 99.
Tin Pyrites, 98.
Tin Stone, 98.
Titanite, 101.
Titanium, 101.
Toad's-eye-tin, 98.
Tombac, 45.
Tobaz, 15.
Tritoxide, 11.
Tungsten, 102.
Tungstic Acid, 103.
Tungstous Acid, 103.
Turbith Mineral, 74.
Turquoise, 15.
Tutenag, 45.
Tutty, 33.
Type-metal, 21, 67.
Uranglimmer, 104.
Uranium, 103.
Uranochre, 104.
Vanadiate of Lead, 105.
Vanadic Acid, 105.
Vanadic Anhydride, 105.
Vanadic Oxide, 105.
Vanadium, 105.
Vanadous Acid, 105.
Veins, 113.
Venus, 41.
Verdigris, 43.
Vermillion, 74.

Violet-brown Oxide of Molybdenum, 76.
Vitreous Copper Ore, 42.
Vitrification, 19.
Volatility, 10.
Water Silver, 74.
Welding, 58, 82.
White Copper, 45, 77.
White Lead, 64.
White Oxide of Titanium, 101.
White Oxide of Antimony, 20.
White Oxide of Arsenic, 24.
White Oxide of Cerium, 37.
White Oxide of Molybdenum, 76.
White Oxide of Zinc, 107.
White Vitriol, 108.
Wire of Silver, 91.
Witherite, 29.
Wolfram, 102.
Wolframium, 102.
Wood-tin, 98.
Wrought Iron, 60.
Yellow Copper Ore, 42.
Yellow Oxide of Antimony, 20.
Yellow Oxide of Bismuth, 30.
Yellow Oxide of Cerium, 37.
Yellow Oxide of Gold, 52.
Yellow Oxide of Tin, 99.
Ytterbite, 105.
Yttrium, 106.
Zaffre, 24, 39.
Zinc, 106.
Zircon, 109.
Zirconia, 109.
Zirconium, 109.

By the same Author.

THE STRANGER'S GUIDE TO THE BEDFORD SCHOOLS: being a complete Handbook for those persons who may wish to obtain for their sons either a Free Classical or Commercial Education. With two superior engravings of the Schools. Crown 8vo., cloth, 1s.

OPINIONS OF THE PRESS.

"This is a publication which cannot fail to commend itself to those for whom it has been designed. Of all questions, short of religion, there is none which claims more of our attention than the education of youth, and it is a pleasing sign of the times that this question is being discussed with a view to its being placed on a broader and firmer basis than our ancestors were able to establish. But though we claim for the present age a marked advance in the theory and practice of education, it is to the past we must look for most of those benevolent gifts which brought the source of knowledge within reach of even the poorest—gifts which have earned for givers the reverence of ages, and have entitled them to be placed amongst the foremost benefactors of mankind. The Charterhouse of Sir Thomas Sutton, the magnificent Hospital of George Heriot, and the Charity of Sir William Harpur—three out of the many similar institutions of our land—have no rivals, even in these days of progress and increased enlightenment; they will stand out in bold relief as the princely benefactions of men who were useful and excellent members of society when living, and in death are still the patrons and friends of their species. Our present notice, however, deals only with the last named of these public donors. It is needless for us to enter into particulars of Sir William Harpur's Deed of Gift, nor is there any necessity for commenting on the incalculable blessings it has been the means of diffusing. We therefore confine ourselves to a brief notice of Mr. Blyth's pamphlet, and in so doing we give our hearty appreciation of its merits, both as regards design and execution. It is evidently the work of one who has fully studied the subject he treats of, and has brought to bear on that subject an intelligence that displays itself in every page. The book is ostensibly intended for those who are strangers to the town of Bedford, but it may be perused with advantage by all who are desirous of increasing their knowledge of one of these most important institutions of the borough. Full particulars as to the mode of applying for the benefits of the charity, statistics as to its growth and present condition, and a condensed account of the various legal enactments affecting it, combine to form a very perfect and a very readable book, and one which, we have no doubt, will meet with a large sale."—*Leighton Buzzard Times*, August 5, 1864.

"The 'Stranger's Guide' is a succinct description of the Bedford Schools, founded by Sir William and Lady Harpur, and holding forth advantages to those classes who rarely have such placed within their reach. It would appear that on occupying a dwelling-house, rented as low as £10, within the Borough of Bedford, without waiting till a parochial settlement shall be acquired, strangers to Bedford may obtain admission to these schools for all their boys as soon as they arrive at their intended residence in the town. To possess themselves of this benefit, they have to pay only ten guineas to the Trustees of the Bedford Charity, in place of a rent settlement, and one guinea a-year, in half-yearly payments in advance, for each son continuing in the Grammar and [Upper] Commercial Schools....The little work is clearly written, and states the time, place, and regulations necessary to be attended to in desiring to obtain admission to the Schools.—*Boys' Miscellany and Paper*, August 13, 1864.

"The world-wide celebrated Schools of Bedford are described historically, &c., and full directions given how the benefits of these seminaries of learning may be obtained. A manual of great value.—*Baptist Messenger*, November, 1864.

"This is a complete handbook for those who may wish to obtain for their sons either a free classical or commercial education. It has two superior engravings of the Schools, and is published at sixpence, post free. The Guide is written by a resident, who evidently possesses a thorough knowledge of the subject, and we have no doubt that it will be found of great value, especially to persons who may desire to have a residence in Bedford, for the purpose of availing themselves of the benefits derivable from the Schools for their sons."—*Cambridge Independent Press*, July 23, 1864.

"Full of educational information, and very agreeable for families about to take up their residence in Bedford town."—*Christian World*, September 2, 1864.

"This little work is one of a very useful character. It describes the foundation and growth of those enormous charities for which the town of Bedford holds a paramount celebrity, and also what constitutes the right of admission to the benefit of those charities and their schools. We recommend the book, more especially to visitors and intending residents in Bedford."—*Bedfordshire Express*, July 23, 1864.

"We have just had a little book placed in our hands bearing the above title, which it so well deserves. Although the author's name is not given, the careful and intelligent style in which the book is written, is sufficient to convince us that he is a gentleman of no ordinary ability. After a perusal of the book, we feel great pleasure in recommending it to those who intend to visit Bedford; also to many residents, who would not regret devoting a portion of their leisure to this little useful book, which is well and carefully printed."—*Luton Advertiser*, June 3, 1864.

THE BEDFORD DIRECTORY AND ALMANACK: containing a Brief Sketch of the History of Bedford, the Population of the Town, the Borough and its Representation, the Churches and Chapels, the Harpur Schools, Directory of Householders, Religious Societies, &c., &c., Crown 8vo., cloth, 1s. 6d. *Burt, Bedford*, 1866.

A MEMOIR OF THE LATE JOSEPH JAMES INSULL. Crown 8vo., cloth, with photograph, 1s. Third edition.

OPINIONS OF THE PRESS.

"A very interesting memoir....He was a sincere Christian, and devoted to the cause of religion. This brief memoir will therefore be highly treasured by those who knew him so well....It is a third edition, and has been revised by Mr. T. Blyth."—*Cambridge Independent Press*, July 23, 1864.

"A concise little memoir, written in the spirit of affection for the departed....The memoir is short, but sufficient to continue to posterity the remembrance of a good and useful man."—*Hertfordshire Express*, July 23, 1864.

"In want of a more extended life we cannot but thank the author for his warm-hearted yet justly-drawn picture of Mr. Insull, and we have much pleasure in commending it to all who wish to possess a tribute to his Christian excellence."—*Dunstable Chronicle*, August 5, 1864.

THE BEDFORD DIRECTORY. Crown 8vo., cloth, 1s. *Burt, Bedford*, 1867.

A MEMOIR OF THE LATE JOHN JUKES. Crown 8vo., with photograph and copy of autograph, cloth, 2s.

A BIOGRAPHICAL SKETCH OF SIR WILLIAM HARPUR, Knight, Founder of the Bedford Schools, and Lord Mayor of London in 1561. A Lecture delivered in Bedford, on Thursday, March 24th, 1864, by T. A. Blyth. Crown 8vo., cloth, 6d.

THE BEDFORD DIRECTORY AND HISTORY OF THE TOWN, containing a Sketch of the History of Bedford, its Churches, Chapels, Schools, Britannia Iron Works, Bridge, General Infirmary, House of Industry, Jail, &c., &c. Crown 8vo., cloth, 2s. *Carter, Bedford*, 1869.

JOHN BUNYAN AND HIS CHURCH AT BEDFORD, containing an authentic Historical Account of the above Church, from its Foundation to the Present Time. Crown 8vo., cloth, 1s. 6d.

THE HISTORY OF BEDFORD AND VISITOR'S GUIDE BOOK. Demy 8vo., 327 pp., cloth, with numerous illustrations. In the Press. 7s. 6d.

Longmans, London.

J. R. PORTER, PRINTER, 7, HIGH STREET, BEDFORD.

GENERAL LIST OF WORKS

PUBLISHED BY

MESSRS. LONGMANS, GREEN, AND CO.

PATERNOSTER ROW, LONDON.

History, Politics, Historical Memoirs, &c.

The HISTORY of ENGLAND from the Fall of Wolsey to the Defeat of the Spanish Armada. By JAMES ANTHONY FROUDE, M.A. late Fellow of Exeter College, Oxford.

LIBRARY EDITION, 12 VOLS. 8vo. price £8 18*s.*
CABINET EDITION, now appearing, in 12 vols. crown 8vo. price 6*s.* each.

The HISTORY of ENGLAND from the Accession of James II. By Lord MACAULAY.

LIBRARY EDITION, 5 vols. 8vo. £4.
CABINET EDITION, 8 vols. post 8vo. 48*s.*
PEOPLE'S EDITION, 4 vols. crown 8vo. 16*s.*

LORD MACAULAY'S WORKS. Complete and Uniform Library Edition. Edited by his Sister, Lady TREVELYAN. 8 vols. 8vo. with Portrait, price £5 5*s.* cloth, or £8 8*s.* bound in tree-calf by Rivière.

An ESSAY on the HISTORY of the ENGLISH GOVERNMENT and Constitution, from the Reign of Henry VII. to the Present Time. By JOHN EARL RUSSELL. Fourth Edition, revised. Crown 8vo. 6*s.*

SELECTIONS from SPEECHES of EARL RUSSELL, 1817 to 1841, and from Despatches, 1859 to 1865; with Introductions. 2 vols. 8vo. 28*s.*

VARIETIES of VICE-REGAL LIFE. By Sir WILLIAM DENISON, K.C.B. late Governor-General of the Australian Colonies, and Governor of Madras. With Two Maps. 2 vols. 8vo. 28*s.*

On PARLIAMENTARY GOVERNMENT in ENGLAND: Its Origin, Development, and Practical Operation. By ALPHEUS TODD, Librarian of the Legislative Assembly of Canada. 2 vols. 8vo. price £1 17*s.*

LAND SYSTEMS and INDUSTRIAL ECONOMY of IRELAND, ENG-LAND, and CONTINENTAL COUNTRIES. By T. E. CLIFFE LESLIE, LL.B. of Lincoln's Inn, Barrister-at-Law. 8vo. 12*s.*

A HISTORICAL ACCOUNT of the NEUTRALITY of GREAT BRI-TAIN DURING the AMERICAN CIVIL WAR. By MOUNTAGUE BERNARD, M.A. Chichele Professor of International Law and Diplomacy in the University of Oxford. Royal 8vo. 16*s.*

The HISTORY of ENGLAND during the Reign of George the Third. By the Right Hon. W. N. MASSEY. Cabinet Edition. 4 vols. post 8vo. 24*s.*

The CONSTITUTIONAL HISTORY of ENGLAND, since the Accession of George III. 1760—1860. By Sir THOMAS ERSKINE MAY, C.B. Second Edition. 2 vols. 8vo. 33*s.*

HISTORICAL STUDIES. By HERMAN MERIVALE, M.A. 8vo. 12*s.* 6*d.*

The OXFORD REFORMERS of 1498—John Colet, Erasmus, and Thomas More; being a History of their Fellow-work. By FREDERIC SEEBOHM. Second Edition, enlarged. 8vo. 14*s.*

A HISTORY of WALES, derived from Authentic Sources. By JANE WILLIAMS, Ysgafell. 8vo. 14*s.*

LECTURES on the HISTORY of ENGLAND, from the earliest Times to the Death of King Edward II. By WILLIAM LONGMAN. With Maps and Illustrations. 8vo. 15*s.*

The HISTORY of the LIFE and TIMES of EDWARD the THIRD. By WILLIAM LONGMAN. With 9 Maps, 8 Plates, and 16 Woodcuts. 2 vols. 8vo. 28*s.*

HISTORY of the NORMAN KINGS of ENGLAND, from a New Collation of the Contemporary Chronicles. By THOMAS COBBE, Barrister, of the Inner Temple. 8vo. price 16*s.*

The OVERTHROW of the GERMANIC CONFEDERATION by PRUSSIA in 1866. By Sir ALEXANDER MALET, Bart. K.C.B. With 5 Maps. 8vo. 18*s.*

The MILITARY RESOURCES of PRUSSIA and FRANCE, and RECENT CHANGES in the ART of WAR. By Lieut.-Col. CHESNEY, R.E. and HENRY REEVE, D.C.L. Crown 8vo. price 7*s.* 6*d.*

WATERLOO LECTURES: a Study of the Campaign of 1815. By Colonel CHARLES C. CHESNEY, R.E. late Professor of Military Art and History in the Staff College. New Edition. 8vo. with Map, 10*s.* 6*d.*

DEMOCRACY in AMERICA. By ALEXIS DE TOCQUEVILLE. Translated by HENRY REEVE. 2 vols. 8vo. 21*s.*

HISTORY of the REFORMATION in EUROPE in the Time of Calvin. By J. H. MERLE D'AUBIGNÉ, D.D. VOLS. I. and II. 8vo. 28*s.* VOL. III. 12*s.* VOL. IV. 16*s.* VOL. V. price 16*s.*

HISTORY of FRANCE, from Clovis and Charlemagne to the Accession of Napoléon III. By EYRE EVANS CROWE. 5 vols. 8vo. £4 13*s.*

CHAPTERS from FRENCH HISTORY; St. Louis, Joan of Arc, Henri IV. with Sketches of the Intermediate Periods. By J. H. GURNEY, M.A. New Edition. Fcp. 8vo. 6*s.* 6*d.*

MEMOIR of POPE SIXTUS the FIFTH. By Baron HUBNER. Translated from the Original in French, with the Author's sanction, by HUBERT E. H. JERNINGHAM. 2 vols. 8vo. [*Nearly ready.*

IGNATIUS LOYOLA and the EARLY JESUITS. By STEWART ROSE. 8vo. with Portrait, price 16*s.*

The HISTORY of GREECE. By C. THIRLWALL, D.D. Lord Bishop of St. David's. 8 vols. fcp. 8vo. price 28*s.*

GREEK HISTORY from Themistocles to Alexander, in a Series of Lives from Plutarch. Revised and arranged by A. H. CLOUGH. Fcp. with 44 Woodcuts, 6*s.*

CRITICAL HISTORY of the LANGUAGE and LITERATURE of Ancient Greece. By WILLIAM MURE, of Caldwell. 5 vols. 8vo. £3 9*s*.

The TALE of the GREAT PERSIAN WAR, from the Histories of Herodotus. By GEORGE W. COX, M.A. New Edition. Fcp. 3*s*. 6*d*.

HISTORY of the LITERATURE of ANCIENT GREECE. By Professor K. O. MÜLLER. Translated by the Right Hon. Sir GEORGE CORNEWALL LEWIS, Bart. and by J. W. DONALDSON, D.D. 3 vols. 8vo. 21*s*.

HISTORY of the CITY of ROME from its Foundation to the Sixteenth Century of the Christian Era. By THOMAS H. DYER, LL.D. 8vo. with 2 Maps, 15*s*.

The HISTORY of ROME. By WILHELM IHNE. Translated and revised by the Author. VOLS. I. and II. 8vo. [*Nearly ready.*

HISTORY of the ROMANS under the EMPIRE. By the Very Rev. C. MERIVALE, D.C.L. Dean of Ely. 8 vols. post 8vo. 48*s*.

The FALL of the ROMAN REPUBLIC; a Short History of the Last Century of the Commonwealth. By the same Author. 12mo. 7*s*. 6*d*.

The STUDENT'S MANUAL of the HISTORY of INDIA, from the Earliest Period to the Present. By Colonel MEADOWS TAYLOR, M.R.A.S. M.R.I.A. Author of 'The Confessions of a Thug.' Crown 8vo. [*In the press.*

The HISTORY of INDIA, from the Earliest Period to the close of Lord Dalhousie's Administration. By JOHN CLARK MARSHMAN. 3 vols. crown 8vo. 22*s*. 6*d*.

INDIAN POLITY: a View of the System of Administration in India. By Lieutenant-Colonel GEORGE CHESNEY, Fellow of the University of Calcutta. New Edition, revised; with Map. 8vo. price 21*s*.

HOME POLITICS; being a consideration of the Causes of the Growth of Trade in relation to Labour, Pauperism, and Emigration. By DANIEL GRANT. 8vo. 7*s*.

REALITIES of IRISH LIFE. By W. STEUART TRENCH, Land Agent in Ireland to the Marquess of Lansdowne, the Marquess of Bath, and Lord Digby. Fifth Edition. Crown 8vo. price 6*s*.

The STUDENT'S MANUAL of the HISTORY of IRELAND. By MARY F. CUSACK, Authoress of the 'Illustrated of Ireland, from the Earliest Period to the Year of Catholic Emancipation.' Crown 8vo. price 6*s*.

CRITICAL and HISTORICAL ESSAYS contributed to the *Edinburgh Review*. By the Right Hon. LORD MACAULAY.

CABINET EDITION, 4 vols. post 8vo. 24*s*. LIBRARY EDITION, 3 vols. 8vo. 36*s*.
PEOPLE'S EDITION, 2 vols. crown 8vo. 8*s*. STUDENT'S EDITION, 1 vol. cr. 8vo. 6*s*.

HISTORY of EUROPEAN MORALS, from Augustus to Charlemagne. By W. E. H. LECKY, M.A. Second Edition. 2 vols. 8vo. price 28*s*.

HISTORY of the RISE and INFLUENCE of the SPIRIT of RATIONALISM in EUROPE. By W. E. H. LECKY, M.A. Cabinet Edition, being the Fourth. 2 vols. crown 8vo. price 16*s*.

GOD in HISTORY; or, the Progress of Man's Faith in the Moral Order of the World. By Baron BUNSEN. Translated by SUSANNA WINKWORTH; with a Preface by Dean STANLEY. 3 vols. 8vo. price 42*s*.

The HISTORY of PHILOSOPHY, from Thales to Comte. By GEORGE HENRY LEWES. Third Edition. 2 vols. 8vo. 30*s.*

The MYTHOLOGY of the ARYAN NATIONS. By GEORGE W. COX, M.A. late Scholar of Trinity College, Oxford, Joint-Editor, with the late Professor Brande, of the Fourth Edition of 'The Dictionary of Science, Literature, and Art,' Author of 'Tales of Ancient Greece,' &c. 2 vols. 8vo. 28*s.*

EGYPT'S PLACE in UNIVERSAL HISTORY; an Historical Investigation. By Baron BUNSEN, D.C.L. Translated by C. H. COTTRELL, M.A. With Additions by S. BIRCH, LL.D. 5 vols. 8vo. price £8 14*s.* 6*d.*

HISTORY of CIVILISATION in England and France, Spain and Scotland. By HENRY THOMAS BUCKLE. New Edition of the entire Work, with a complete INDEX. 3 vols. crown 8vo. 24*s.*

HISTORY of the CHRISTIAN CHURCH, from the Ascension of Christ to the Conversion of Constantine. By E. BURTON, D.D. late Prof. of Divinity in the Univ. of Oxford. Eighth Edition. Fcp. 3*s.* 6*d.*

SKETCH of the HISTORY of the CHURCH of ENGLAND to the Revolution of 1688. By the Right Rev. T. V. SHORT, D.D. Lord Bishop of St. Asaph. Eighth Edition. Crown 8vo. 7*s.* 6*d.*

HISTORY of the EARLY CHURCH, from the First Preaching of the Gospel to the Council of Nicæa. A.D. 325. By ELIZABETH M. SEWELL, Author of 'Amy Herbert.' New Edition, with Questions. Fcp. 4*s.* 6*d.*

The ENGLISH REFORMATION. By F. C. MASSINGBERD, M.A. Chancellor of Lincoln and Rector of South Ormsby. Fourth Edition, revised. Fcp. 8vo. 7*s.* 6*d.*

MAUNDER'S HISTORICAL TREASURY; comprising a General Introductory Outline of Universal History, and a series of Separate Histories. Latest Edition, revised and brought down to the Present Time by the Rev. GEORGE WILLIAM COX, M.A. Fcp. 6*s.* cloth, or 9*s.* 6*d.* calf.

WOODWARD'S HISTORICAL and CHRONOLOGICAL ENCYCLOPÆDIA.—The copious 'Encyclopædia of Chronology and History,' projected and left unfinished by the late B. B. WOODWARD, B.A. F.S.A. Librarian to the Queen at Windsor, is in an advanced state of preparation, and will be completed by Mr. W. L. R. CATES, Editor of the *Dictionary of General Biography*, the friend, and for ten years the collaborateur, of Mr. WOODWARD.

Biographical Works.

The LIFE and LETTERS of FARADAY. By Dr. BENCE JONES, Secretary of the Royal Institution. Second Edition, thoroughly revised. 2 vols. 8vo. with Portrait, and Eight Engravings on Wood, price 28*s.*

FARADAY as a DISCOVERER. By JOHN TYNDALL, LL.D. F.R.S. Professor of Natural Philosophy in the Royal Institution. New and Cheaper Edition, with Two Portraits. Fcp. 8vo. 3*s.* 6*d.*

The LIFE and LETTERS of the Rev. SYDNEY SMITH. Edited by his Daughter, Lady HOLLAND, and Mrs. AUSTIN. New Edition, complete in One Volume. Crown 8vo. price 6*s.*

A MEMOIR of GEORGE EDWARD LYNCH COTTON, D.D. late Lord Bishop of Calcutta; with Selections from his Journals and Letters. Edited by Mrs. COTTON. [*In preparation.*

The LIFE of OLIVER CROMWELL, to the Death of Charles I. By J. R. ANDREWS, Barrister-at-Law. 8vo. 14*s.*

DICTIONARY of GENERAL BIOGRAPHY; containing Concise Memoirs and Notices of the most Eminent Persons of all Countries, from the Earliest Ages to the Present Time. Edited by W. L. R. CATES. 8vo. 21*s.*

LIVES of the TUDOR PRINCESSES, including Lady Jane Grey and her Sisters. By AGNES STRICKLAND, Author of 'Lives of the Queens of England.' Post 8vo. with Portrait, &c. 12*s.* 6*d.*

LIVES of the QUEENS of ENGLAND. By AGNES STRICKLAND. Library Edition, newly revised; with Portraits of every Queen, Autographs, and Vignettes. 8 vols. post 8vo. 7*s.* 6*d.* each.

MEMOIRS of BARON BUNSEN. Drawn chiefly from Family Papers by his Widow, FRANCES Baroness BUNSEN. Second Edition, abridged; with 2 Portraits and 4 Woodcuts. 2 vols. post 8vo. 21*s.*

The LETTERS of the Right Hon. Sir GEORGE CORNEWALL LEWIS, Bart. to various Friends. Edited by his Brother, the Rev. Canon Sir G. F. LEWIS, Bart. 8vo. with Portrait, price 14*s.*

LIFE of the DUKE of WELLINGTON. By the Rev. G. R. GLEIG, M.A. Popular Edition, carefully revised; with copious Additions. Crown 8vo. with Portrait, 5*s.*

HISTORY of MY RELIGIOUS OPINIONS. By J. H. NEWMAN, D.D. Being the Substance of Apologia pro Vitâ Suâ. Post 8vo. 6*s.*

FATHER MATHEW: a Biography. By JOHN FRANCIS MAGUIRE, M.P. for Cork. Popular Edition, with Portrait. Crown 8vo. 3*s.* 6*d.*

FELIX MENDELSSOHN'S LETTERS from *Italy and Switzerland*, and *Letters from* 1833 *to* 1847, translated by Lady WALLACE. New Edition with Portrait. 2 vols. crown 8vo. 5*s.* each.

MEMOIRS of SIR HENRY HAVELOCK, K.C.B. By JOHN CLARK MARSHMAN. Cabinet Edition, with Portrait. Crown 8vo. price 3*s.* 6*d.*

CAPTAIN COOK'S LIFE, VOYAGES, and DISCOVERIES. 18mo. Woodcuts, 2*s.* 6*d.*

VICISSITUDES of FAMILIES. By Sir J. BERNARD BURKE, C.B. Ulster King of Arms. New Edition, remodelled and enlarged. 2 vols. crown 8vo. 21*s.*

THE EARLS of GRANARD: a Memoir of the Noble Family of Forbes. Written by Admiral the Hon. JOHN FORBES, and edited by GEORGE ARTHUR HASTINGS, present Earl of Granard, K.P. 8vo. 10*s.*

ESSAYS in ECCLESIASTICAL BIOGRAPHY. By the Right Hon. Sir J. STEPHEN, LL.D. Cabinet Edition, being the Fifth. Crown 8vo. 7*s.* 6*d.*

MAUNDER'S BIOGRAPHICAL TREASURY. Thirteenth Edition, reconstructed, thoroughly revised, and in great part rewritten; with about 1,000 additional Memoirs and Notices, by W. L. R. CATES. Fcp. 6*s.*

LETTERS and LIFE of FRANCIS BACON, including all his Occasional Works. Collected and edited, with a Commentary, by J. SPEDDING, Trin. Coll. Cantab. VOLS. I. and II. 8vo. 24*s.* VOLS. III. and IV. 24*s.* VOL. V. price 12*s.*

Criticism, Philosophy, Polity, &c.

The INSTITUTES of JUSTINIAN; with English Introduction, Translation, and Notes. By T. C. SANDARS, M.A. Barrister, late Fellow of Oriel Coll. Oxon. New Edition. 8vo. 15*s.*

SOCRATES and the SOCRATIC SCHOOLS. Translated from the German of Dr. E. ZELLER, with the Author's approval, by the Rev. OSWALD J. REICHEL, B.C.L. and M.A. Crown 8vo. 8*s.* 6*d.*

The STOICS, EPICUREANS, and SCEPTICS. Translated from the German of Dr. E. ZELLER, with the Author's approval, by OSWALD J. REICHEL, B.C.L. and M.A. Crown 8vo. price 14*s.*

The ETHICS of ARISTOTLE, illustrated with Essays and Notes. By Sir A. GRANT, Bart. M.A. LL.D. Second Edition, revised and completed. 2 vols. 8vo. price 28*s.*

The NICOMACHEAN ETHICS of ARISTOTLE newly translated into English. By R. WILLIAMS, B.A. Fellow and late Lecturer of Merton College, and sometime Student of Christ Church, Oxford. 8vo. 12*s.*

ELEMENTS of LOGIC. By R. WHATELY, D.D. late Archbishop of Dublin. New Edition. 8vo. 10*s.* 6*d.* crown 8vo. 4*s.* 6*d.*

Elements of Rhetoric. By the same Author. New Edition. 8vo. 10*s.* 6*d.* crown 8vo. 4*s.* 6*d.*

English Synonymes. By E. JANE WHATELY. Edited by Archbishop WHATELY. 5th Edition. Fcp. 3*s.*

BACON'S ESSAYS with ANNOTATIONS. By R. WHATELY, D.D. late Archbishop of Dublin. Sixth Edition. 8vo. 10*s.* 6*d.*

LORD BACON'S WORKS, collected and edited by J. SPEDDING, M.A. R. L. ELLIS, M.A. and D. D. HEATH. New and Cheaper Edition. 7 vols. 8vo. price £3 13*s.* 6*d.*

ENGLAND and IRELAND. By JOHN STUART MILL. Fifth Edition, vo. 1*s.*

The SUBJECTION of WOMEN. By JOHN STUART MILL. New Edition. Post 8vo. 5*s.*

On REPRESENTATIVE GOVERNMENT. By JOHN STUART MILL. Third Edition. 8vo. 9*s.* Crown 8vo. 2*s.*

On LIBERTY. By JOHN STUART MILL. Fourth Edition. Post 8vo. 7*s.* 6*d.* Crown 8vo. 1*s.* 4*d.*

Principles of Political Economy. By the same Author. Sixth Edition. 2 vols. 8vo. 30*s.* Or in 1 vol. crown 8vo. 5*s.*

A System of Logic, Ratiocinative and Inductive. By the same Author. Seventh Edition. Two vols. 8vo. 25*s.*

ANALYSIS of Mr. MILL'S SYSTEM of LOGIC. By W. STEBBING, M.A. Fellow of Worcester College, Oxford. New Edition. 12mo. 3*s.* 6*d.*

UTILITARIANISM. By JOHN STUART MILL. Third Edition. 8vo. 5*s.*

DISSERTATIONS and DISCUSSIONS, POLITICAL, PHILOSOPHICAL, and HISTORICAL. By JOHN STUART MILL. Second Edition, revised. 3 vols. 8vo. 36*s.*

EXAMINATION of Sir W. HAMILTON'S PHILOSOPHY, and of the Principal Philosophical Questions discussed in his Writings. By JOHN STUART MILL. Third Edition. 8vo. 16*s.*

An OUTLINE of the NECESSARY LAWS of THOUGHT: a Treatise on Pure and Applied Logic. By the Most Rev. WILLIAM, Lord Archbishop of York, D.D. F.R.S. Ninth Thousand. Crown 8vo. 5*s.* 6*d.*

The ELEMENTS of POLITICAL ECONOMY. By HENRY DUNNING MACLEOD, M.A. Barrister-at-Law. 8vo. 16*s.*

A Dictionary of Political Economy; Biographical, Bibliographical, Historical, and Practical. By the same Author. VOL. I. royal 8vo. 30*s.*

The ELECTION of REPRESENTATIVES, Parliamentary and Municipal; a Treatise. By THOMAS HARE, Barrister-at-Law. Third Edition, with Additions. Crown 8vo. 6*s.*

SPEECHES of the RIGHT HON. LORD MACAULAY, corrected by Himself. People's Edition, crown 8vo. 3*s.* 6*d.*

Lord Macaulay's Speeches on Parliamentary Reform in 1831 and 1832. 16mo. 1*s.*

INAUGURAL ADDRESS delivered to the University of St. Andrews. By JOHN STUART MILL. 8vo. 5*s.* People's Edition, crown 8vo. 1*s.*

A DICTIONARY of the ENGLISH LANGUAGE. By R. G. LATHAM, M.A. M.D. F.R.S. Founded on the Dictionary of Dr. SAMUEL JOHNSON, as edited by the Rev. H. J. TODD, with numerous Emendations and Additions. In Four Volumes, 4to. price £7.

THESAURUS of ENGLISH WORDS and PHRASES, classified and arranged so as to facilitate the Expression of Ideas, and assist in Literary Composition. By P. M. ROGET, M.D. New Edition. Crown 8vo. 10*s.* 6*d.*

LECTURES on the SCIENCE of LANGUAGE, delivered at the Royal Institution. By MAX MÜLLER, M.A. Fellow of All Souls College, Oxford. 2 vols. 8vo. price 30*s.*

CHAPTERS on LANGUAGE. By FREDERIC W. FARRAR, F.R.S. late Fellow of Trin. Coll. Cambridge. Crown 8vo. 8*s.* 6*d.*

WORD-GOSSIP; a Series of Familiar Essays on Words and their Peculiarities. By the Rev. W. L. BLACKLEY, M.A. Fcp. 8vo. 5*s.*

A BOOK ABOUT WORDS. By G. F. GRAHAM, Author of 'English, or the Art of Composition,' &c. Fcp. 8vo. price 3*s.* 6*d.*

The DEBATER; a Series of Complete Debates, Outlines of Debates, and Questions for Discussion. By F. ROWTON. Fcp. 6*s.*

MANUAL of ENGLISH LITERATURE, Historical and Critical. By THOMAS ARNOLD, M.A. Second Edition. Crown 8vo. price 7*s.* 6*d.*

SOUTHEY'S DOCTOR, complete in One Volume. Edited by the Rev. J. W. WARTER, B.D. Square crown 8vo. 12*s.* 6*d.*

HISTORICAL and CRITICAL COMMENTARY on the OLD TESTAMENT; with a New Translation. By M. M. KALISCH, Ph.D. VOL. I. *Genesis*, 8vo. 18*s.* or adapted for the General Reader, 12*s.* VOL. II. *Exodus*, 15*s.* or adapted for the General Reader, 12*s.* VOL. III. *Leviticus*, PART I. 15*s.* or adapted for the General Reader, 8*s.*

A HEBREW GRAMMAR, with EXERCISES. By M. M. KALISCH, Ph.D. PART I. *Outlines with Exercises*, 8vo. 12*s*. 6*d*. KEY, 5*s*. PART II. *Exceptional Forms and Constructions*, 12*s*. 6*d*.

A LATIN-ENGLISH DICTIONARY. By J. T. WHITE, D.D. of Corpus Christi College, and J. E. RIDDLE, M.A. of St. Edmund Hall, Oxford. Third Edition, revised. 2 vols. 4to. pp. 2,128, price 42*s*. cloth.

White's College Latin-English Dictionary (Intermediate Size), abridged for the use of University Students from the Parent Work (as above). Medium 8vo. pp. 1,048, price 18*s*. cloth.

White's Junior Student's Complete Latin-English and English-Latin Dictionary. New Edition. Square 12mo. pp. 1,058, price 12*s*.

Separately { The ENGLISH-LATIN DICTIONARY, price 5*s*. 6*d*. / The LATIN-ENGLISH DICTIONARY, price 7*s*. 6*d*.

An ENGLISH-GREEK LEXICON, containing all the Greek Words used by Writers of good authority. By C. D. YONGE, B.A. New Edition. 4to. 21*s*.

Mr. YONGE'S NEW LEXICON, English and Greek, abridged from his larger work (as above). Revised Edition. Square 12mo. 8*s*. 6*d*.

A GREEK-ENGLISH LEXICON. Compiled by H. G. LIDDELL, D.D. Dean of Christ Church, and R. SCOTT, D.D. Master of Balliol. Sixth Edition. Crown 4to. price 36*s*.

A Lexicon, Greek and English, abridged from LIDDELL and SCOTT'S *Greek-English Lexicon*. Twelfth Edition. Square 12mo. 7*s*. 6*d*.

A SANSKRIT-ENGLISH DICTIONARY, the Sanskrit words printed both in the original Devanagari and in Roman Letters. Compiled by T. BENFEY, Prof. in the Univ. of Göttingen. 8vo. 52*s*. 6*d*.

WALKER'S PRONOUNCING DICTIONARY of the ENGLISH LANGUAGE. Thoroughly revised Editions, by B. H. SMART. 8vo. 12*s*. 16mo. 6*s*.

A PRACTICAL DICTIONARY of the FRENCH and ENGLISH LANGUAGES. By L. CONTANSEAU. Fourteenth Edition. Post 8vo. 10*s*. 6*d*.

Contanseau's Pocket Dictionary, French and English, abridged from the above by the Author. New Edition, revised. Square 18mo. 3*s*. 6*d*.

NEW PRACTICAL DICTIONARY of the GERMAN LANGUAGE; German-English and English-German. By the Rev. W. L. BLACKLEY, M.A. and Dr. CARL MARTIN FRIEDLÄNDER. Post 8vo. 7*s*. 6*d*.

The MASTERY of LANGUAGES; or, the Art of Speaking Foreign Tongues Idiomatically. By THOMAS PRENDERGAST, late of the Civil Service at Madras. Second Edition. 8vo. 6*s*.

Miscellaneous Works and *Popular Metaphysics.*

The ESSAYS and CONTRIBUTIONS of A. K. H. B., Author of 'The Recreations of a Country Parson.' Uniform Editions:—

Recreations of a Country Parson. By A. K. H. B. FIRST and SECOND SERIES, crown 8vo. 3*s*. 6*d*. each.

The Common-place Philosopher in Town and Country. By A. K. H. B. Crown 8vo. price 3*s.* 6*d.*

Leisure Hours in Town; Essays Consolatory, Æsthetical, Moral, Social, and Domestic. By A. K. H. B. Crown 8vo. 3*s.* 6*d.*

The Autumn Holidays of a Country Parson; Essays contributed to *Fraser's Magazine* and to *Good Words*. By A. K. H. B. Crown 8vo. 3*s.* 6*d.*

The Graver Thoughts of a Country Parson. By A. K. H. B. FIRST and SECOND SERIES, crown 8vo. 3*s.* 6*d.* each.

Critical Essays of a Country Parson, selected from Essays contributed to *Fraser's Magazine*. By A. K. H. B. Crown 8vo. 3*s.* 6*d.*

Sunday Afternoons at the Parish Church of a Scottish University City. By A. K. H. B. Crown 8vo. 3*s.* 6*d.*

Lessons of Middle Age; with some Account of various Cities and Men. By A. K. H. B. Crown 8vo. 3*s.* 6*d.*

Counsel and Comfort spoken from a City Pulpit. By A. K. H. B. Crown 8vo. price 3*s.* 6*d.*

Changed Aspects of Unchanged Truths; Memorials of St. Andrews Sundays. By A. K. H.B. Crown 8vo. 3*s.* 6*d.*

SHORT STUDIES on GREAT SUBJECTS. By JAMES ANTHONY FROUDE, M.A. late Fellow of Exeter Coll. Oxford. Third Edition. 8vo. 12*s.*

LORD MACAULAY'S MISCELLANEOUS WRITINGS:—

LIBRARY EDITION. 2 vols. 8vo. Portrait, 21*s.*
PEOPLE'S EDITION. 1 vol. crown 8vo. 4*s.* 6*d.*

The REV. SYDNEY SMITH'S MISCELLANEOUS WORKS; including his Contributions to the *Edinburgh Review*. Crown 8vo. 6*s.*

The Wit and Wisdom of the Rev. Sydney Smith: a Selection of the most memorable Passages in his Writings and Conversation. 16mo. 3*s.* 6*d.*

TRACES of HISTORY in the NAMES of PLACES; with a Vocabulary of the Roots out of which Names of Places in England and Wales are formed. By FLAVELL EDMUNDS. Crown 8vo. 7*s.* 6*d.*

ESSAYS selected from CONTRIBUTIONS to the *Edinburgh Review*. By HENRY ROGERS. Second Edition. 3 vols. fcp. 21*s.*

Reason and Faith, their Claims and Conflicts. By the same Author. New Edition, accompanied by several other Essays. Crown 8vo. 6*s.* 6*d.*

The Eclipse of Faith; or, a Visit to a Religious Sceptic. By the same Author. Twelfth Edition. Fcp. 5*s.*

Defence of the Eclipse of Faith, by its Author; a rejoinder to Dr. Newman's *Reply*. Third Edition. Fcp. 3*s.* 6*d.*

Selections from the Correspondence of R. E. H. Greyson. By the same Author. Third Edition. Crown 8vo. 7*s.* 6*d.*

FAMILIES of SPEECH, Four Lectures delivered at the Royal Institution of Great Britain. By the Rev. F. W. FARRAR, M.A. F.R.S. late Fellow of Trinity College, Cambridge. Post 8vo. with Two Maps, 5*s.* 6*d.*

CHIPS from a GERMAN WORKSHOP; being Essays on the Science of Religion, and on Mythology, Traditions, and Customs. By MAX MÜLLER, M.A. Fellow of All Souls College, Oxford. Second Edition, revised, with an Index. 2 vols. 8vo. 24*s.*

ANALYSIS of the PHENOMENA of the HUMAN MIND. By JAMES MILL. A New Edition, with Notes, Illustrative and Critical, by ALEXANDER BAIN, ANDREW FINDLATER, and GEORGE GROTE. Edited, with additional Notes, by JOHN STUART MILL. 2 vols. 8vo. price 28*s.*

An INTRODUCTION to MENTAL PHILOSOPHY, on the Inductive Method. By J. D. MORELL, M.A. LL.D. 8vo. 12*s.*

ELEMENTS of PSYCHOLOGY, containing the Analysis of the Intellectual Powers. By the same Author. Post 8vo. 7*s.* 6*d.*

The SECRET of HEGEL: being the Hegelian System in Origin, Principle, Form, and Matter. By J. H. STIRLING. 2 vols. 8vo. 28*s.*

The SENSES and the INTELLECT. By ALEXANDER BAIN, M.D. Professor of Logic in the University of Aberdeen. Third Edition. 8vo. 15*s.*

The EMOTIONS and the WILL. By the same Author. Second Edition. 8vo. 15*s.*

On the STUDY of CHARACTER, including an Estimate of Phrenology. By the same Author. 8vo. 9*s.*

MENTAL and MORAL SCIENCE: a Compendium of Psychology and Ethics. By the same Author. Second Edition. Crown 8vo. 10*s.* 6*d.*

LOGIC, DEDUCTIVE and INDUCTIVE. By the same Author. In TWO PARTS, crown 8vo. 10*s.* 6*d.* Each Part may be had separately:—
PART I. *Deduction*, 4*s.* PART II. *Induction*, 6*s.* 6*d.*

TIME and SPACE; a Metaphysical Essay. By SHADWORTH H. HODGSON. (This work covers the whole ground of Speculative Philosophy.) 8vo. price 16*s.*

The Theory of Practice; an Ethical Inquiry. By the same Author. (This work, in conjunction with the foregoing, completes a system of Philosophy.) 2 vols. 8vo. price 24*s.*

STRONG AND FREE; or, First Steps towards Social Science. By the Author of 'My Life, and What shall I do with it?' 8vo. price 10*s.* 6*d.*

The PHILOSOPHY of NECESSITY; or, Natural Law as applicable to Mental, Moral, and Social Science. By CHARLES BRAY. Second Edition. 8vo. 9*s.*

The Education of the Feelings and Affections. By the same Author. Third Edition. 8vo. 3*s.* 6*d.*

On Force, its Mental and Moral Correlates. By the same Author. 8vo. 5*s.*

CHARACTERISTICS of MEN, MANNERS, OPINIONS, TIMES. By ANTHONY, Third Earl of SHAFTESBURY. Published from the Edition of 1713, with Engravings designed by the Author; and edited, with Marginal Analysis, Notes, and Illustrations, by the Rev. W. M. HATCH, M.A. Fellow of New College, Oxford. 3 vols. 8vo. VOL. I. price 14*s.*

A TREATISE on HUMAN NATURE; being an Attempt to Introduce the Experimental Method of Reasoning into Moral Subjects. By DAVID HUME. Edited, with a Preliminary Dissertation and Notes, by T. H. GREEN, Fellow, and T. H. GROSE, late Scholar, of Balliol College, Oxford. [*In the press.*

ESSAYS MORAL, POLITICAL, and LITERARY. By DAVID HUME. By the same Editors. [*In the press.*

Astronomy, Meteorology, Popular Geography, &c.

OUTLINES of ASTRONOMY. By Sir J. F. W. HERSCHEL, Bart. M.A. Tenth Edition, revised; with 9 Plates and many Woodcuts. 8vo. 18*s.*

OTHER WORLDS THAN OURS; the Plurality of Worlds Studied under the Light of Recent Scientific Researches. By RICHARD A. PROCTOR, B.A. F.R.A.S. With 13 Illustrations (6 of them coloured). Crown 8vo. 10*s.* 6*d.*

SATURN and its SYSTEM. By the same Author. 8vo. with 14 Plates, 14*s.*

CELESTIAL OBJECTS for COMMON TELESCOPES. By the Rev. T. W. WEBB, M.A. F.R.A.S. Second Edition, revised, with a large Map of the Moon, and several Woodcuts. 16mo. 7*s.* 6*d.*

NAVIGATION and NAUTICAL ASTRONOMY (Practical, Theoretical, Scientific) for the use of Students and Practical Men. By J. MERRIFIELD, F.R.A.S and H. EVERS. 8vo. 14*s.*

DOVE'S LAW of STORMS, considered in connexion with the Ordinary Movements of the Atmosphere. Translated by R. H. SCOTT, M.A. T.C.D. 8vo. 10*s.* 6*d.*

PHYSICAL GEOGRAPHY for SCHOOLS and GENERAL READERS. By M. F. MAURY, LL.D. Fcp. with 2 Charts, 2*s.* 6*d.*

M'CULLOCH'S DICTIONARY, Geographical, Statistical, and Historical, of the various Countries, Places, and Principal Natural Objects in the World. New Edition, with the Statistical Information brought up to the latest returns by F. MARTIN. 4 vols. 8vo. with coloured Maps, £4 4*s.*

A GENERAL DICTIONARY of GEOGRAPHY, Descriptive, Physical, Statistical, and Historical: forming a complete Gazetteer of the World. By A. KEITH JOHNSTON, LL.D. F.R.G.S. Revised Edition. 8vo. 31*s.* 6*d.*

A MANUAL of GEOGRAPHY, Physical, Industrial, and Political. By W. HUGHES, F.R.G.S. With 6 Maps. Fcp. 7*s.* 6*d.*

The STATES of the RIVER PLATE: their Industries and Commerce. By WILFRID LATHAM, Buenos Ayres. Second Edition, revised. 8vo. 12*s.*

MAUNDER'S TREASURY of GEOGRAPHY, Physical, Historical, Descriptive, and Political. Edited by W. HUGHES, F.R.G.S. Revised Edition, with 7 Maps and 16 Plates. Fcp. 6*s.* cloth, or 9*s.* 6*d.* bound in calf.

Natural History and *Popular Science.*

ELEMENTARY TREATISE on PHYSICS, Experimental and Applied. Translated and edited from GANOT'S *Eléments de Physique* (with the Author's sanction) by E. ATKINSON, Ph.D. F.C.S. New Edition, revised and enlarged; with a Coloured Plate and 620 Woodcuts. Post 8vo. 15*s.*

The ELEMENTS of PHYSICS or NATURAL PHILOSOPHY. By NEIL ARNOTT, M.D. F.R.S. Physician Extraordinary to the Queen. Sixth Edition, rewritten and completed. Two Parts, 8vo. 21*s.*

SOUND: a Course of Eight Lectures delivered at the Royal Institution of Great Britain. By JOHN TYNDALL, LL.D. F.R.S. New Edition, crown 8vo. with Portrait of *M. Chladni* and 169 Woodcuts, price 9*s.*

HEAT a MODE of MOTION. By Professor JOHN TYNDALL, LL.D. F.R.S. Fourth Edition. Crown 8vo. with Woodcuts, 10*s.* 6*d.*

RESEARCHES on DIAMAGNETISM and MAGNE-CRYSTALLIC ACTION; including the Question of Diamagnetic Polarity. By the same Author. With 6 Plates and many Woodcuts. 8vo. price 14*s.*

NOTES of a COURSE of NINE LECTURES on LIGHT delivered at the Royal Institution of Great Britain in April–June 1869. By the same Author. Crown 8vo. price 1*s.* sewed, or 1*s.* 6*d.* cloth.

LIGHT: Its Influence on Life and Health. By FORBES WINSLOW, M.D. D.C.L. Oxon. (Hon.). Fcp. 8vo. 6*s.*

A TREATISE on ELECTRICITY, in Theory and Practice. By A. DE LA RIVE, Prof. in the Academy of Geneva. Translated by C. V. WALKER, F.R.S. 3 vols. 8vo. with Woodcuts, £3 13*s.*

The CORRELATION of PHYSICAL FORCES. By W. R. GROVE, Q.C. V.P.R.S. Fifth Edition, revised, and followed by a Discourse on Continuity. 8vo. 10*s.* 6*d.* The *Discourse on Continuity*, separately, 2*s.* 6*d.*

MANUAL of GEOLOGY. By S. HAUGHTON, M.D. F.R.S. Revised Edition, with 66 Woodcuts. Fcp. 7*s.* 6*d.*

A GUIDE to GEOLOGY. By J. PHILLIPS, M.A. Professor of Geology in the University of Oxford. Fifth Edition, with Plates. Fcp. 4*s.*

The STUDENT'S MANUAL of ZOOLOGY and COMPARATIVE PHYSIOLOGY. By J. BURNEY YEO, M.B. Resident Medical Tutor and Lecturer on Animal Physiology in King's College, London. [*Nearly ready.*

VAN DER HOEVEN'S HANDBOOK of ZOOLOGY. Translated from the Second Dutch Edition by the Rev. W. CLARK, M.D. F.R.S. 2 vols. 8vo. with 24 Plates of Figures, 60*s.*

Professor OWEN'S LECTURES on the COMPARATIVE ANATOMY and Physiology of the Invertebrate Animals. Second Edition, with 235 Woodcuts. 8vo. 21*s.*

The COMPARATIVE ANATOMY and PHYSIOLOGY of the VERTEBRATE Animals. By RICHARD OWEN, F.R.S. D.C.L. With 1,472 Woodcuts. 3 vols. 8vo. £3 13*s.* 6*d.*

The ORIGIN of CIVILISATION and the PRIMITIVE CONDITION of MAN; Mental and Social Condition of Savages. By Sir JOHN LUBBOCK, Bart. M.P. F.R.S. With 25 Woodcuts. 8vo. price 16*s.*

The PRIMITIVE INHABITANTS of SCANDINAVIA: containing a Description of the Implements, Dwellings, Tombs, and Mode of Living of the Savages in the North of Europe during the Stone Age. By SVEN NILSSON. With 16 Plates of Figures and 3 Woodcuts. 8vo. 18*s.*

BIBLE ANIMALS; being a Description of every Living Creature mentioned in the Scriptures, from the Ape to the Coral. By the Rev. J. G. WOOD, M.A. F.L.S. With about 100 Vignettes on Wood, 8vo. 21*s.*

HOMES WITHOUT HANDS: a Description of the Habitations of Animals, classed according to their Principle of Construction. By Rev. J. G. WOOD, M.A. F.L.S. With about 140 Vignettes on Wood, 8vo. 21*s.*

A FAMILIAR HISTORY of BIRDS. By E. STANLEY, D.D. F.R.S. late Lord Bishop of Norwich. Seventh Edition, with Woodcuts. Fcp. 3*s.* 6*d.*

The HARMONIES of NATURE and UNITY of CREATION. By Dr. GEORGE HARTWIG. 8vo. with numerous Illustrations, 18*s.*

The SEA and its LIVING WONDERS. By the same Author. Third (English) Edition. 8vo. with many Illustrations, 21*s.*

The TROPICAL WORLD. By Dr. GEO. HARTWIG. With 8 Chromoxylographs and 172 Woodcuts. 8vo. 21*s.*

The POLAR WORLD; a Popular Description of Man and Nature in the Arctic and Antarctic Regions of the Globe. By Dr. GEORGE HARTWIG. With 8 Chromoxylographs, 3 Maps, and 85 Woodcuts. 8vo. 21*s.*

KIRBY and SPENCE'S INTRODUCTION to ENTOMOLOGY, or Elements of the Natural History of Insects. 7th Edition. Crown 8vo. 5*s.*

MAUNDER'S TREASURY of NATURAL HISTORY, or Popular Dictionary of Zoology. Revised and corrected by T. S. COBBOLD, M.D. Fcp. with 900 Woodcuts, 6*s.* cloth, or 9*s.* 6*d.* bound in calf.

The TREASURY of BOTANY, or Popular Dictionary of the Vegetable Kingdom; including a Glossary of Botanical Terms. Edited by J. LINDLEY, F.R.S. and T. MOORE, F.L.S. assisted by eminent Contributors. With 274 Woodcuts and 20 Steel Plates. Two Parts, fcp. 12*s.* cloth, or 19*s.* calf.

The ELEMENTS of BOTANY for FAMILIES and SCHOOLS. Tenth Edition, revised by THOMAS MOORE, F.L.S. Fcp. with 154 Woodcuts, 2*s.* 6*d.*

The ROSE AMATEUR'S GUIDE. By THOMAS RIVERS. Ninth Edition. Fcp. 4*s.*

The BRITISH FLORA; comprising the Phænogamous or Flowering Plants and the Ferns. By Sir W. J. HOOKER, K.H. and G. A. WALKER-ARNOTT, LL.D. 12mo. with 12 Plates, 14*s.*

LOUDON'S ENCYCLOPÆDIA of PLANTS; comprising the Specific Character, Description, Culture, History, &c. of all the Plants found in Great Britain. With upwards of 12,000 Woodcuts. 8vo. 42*s.*

MAUNDER'S SCIENTIFIC and LITERARY TREASURY. New Edition, thoroughly revised and in great part re-written, with above 1,000 new Articles, by J. Y. JOHNSON, Corr. M.Z.S. Fcp. 6*s.* cloth, or 9*s.* 6*d.* calf.

A DICTIONARY of SCIENCE, LITERATURE, and ART. Fourth Edition, re-edited by W. T. BRANDE (the original Author), and GEORGE W. COX, M.A. assisted by contributors of eminent Scientific and Literary Acquirements. 3 vols. medium 8vo. price 63*s.* cloth.

Chemistry, Medicine, Surgery, and the *Allied Sciences.*

A DICTIONARY of CHEMISTRY and the Allied Branches of other Sciences. By HENRY WATTS, F.R.S. assisted by eminent Contributors. Complete in 5 vols. medium 8vo. £7 3*s.*

ELEMENTS of CHEMISTRY, Theoretical and Practical. By W. ALLEN MILLER, M.D. &c. Prof. of Chemistry, King's Coll. London. Fourth Edition. 3 vols. 8vo. £3. PART I. CHEMICAL PHYSICS, 15*s.* PART II. INORGANIC CHEMISTRY, 21*s.* PART III. ORGANIC CHEMISTRY, 24*s.*

A MANUAL of CHEMISTRY, Descriptive and Theoretical. By WILLIAM ODLING, M.B. F.R.S. PART I. 8vo. 9*s.* PART II. *just ready.*

OUTLINES of CHEMISTRY; or, Brief Notes of Chemical Facts. By WILLIAM ODLING, M.B. F.R.S. Crown 8vo. *7s. 6d.*

A Course of Practical Chemistry, for the use of Medical Students. By the same Author. New Edition, with 70 Woodcuts. Crown 8vo. *7s. 6d.*

Lectures on Animal Chemistry, delivered at the Royal College of Physicians in 1865. By the same Author. Crown 8vo. *4s. 6d.*

LECTURES on the CHEMICAL CHANGES of CARBON. Delivered at the Royal Institution of Great Britain. By WILLIAM ODLING, M.B. F.R.S. Reprinted from the *Chemical News*, with Notes by W. CROOKES, F.R.S. Crown 8vo. price *4s. 6d.*

HANDBOOK of CHEMICAL ANALYSIS, adapted to the UNITARY *System* of Notation. By F. T. CONINGTON, M.A. F.C.S. Post 8vo. *7s. 6d.* —CONINGTON'S *Tables of Qualitative Analysis*, price *2s. 6d.*

A TREATISE on MEDICAL ELECTRICITY, THEORETICAL and PRACTICAL; and its Use in the Treatment of Paralysis, Neuralgia, and other Diseases. By JULIUS ALTHAUS, M.D. &c. Senior Physician to the Infirmary for Epilepsy and Paralysis. Second Edition, revised and partly re-written. Post 8vo. price *15s.*

The DIAGNOSIS, PATHOLOGY, and TREATMENT of DISEASES of Women; including the Diagnosis of Pregnancy. By GRAILY HEWITT, M.D. Second Edition, enlarged; with 116 Woodcut Illustrations. 8vo. *24s.*

LECTURES on the DISEASES of INFANCY and CHILDHOOD. By CHARLES WEST, M.D. &c. Fifth Edition, revised and enlarged. 8vo. *16s.*

A SYSTEM of SURGERY, Theoretical and Practical. In Treatises by Various Authors. Edited by T. HOLMES, M.A. &c. Surgeon and Lecturer on Surgery at St. George's Hospital, and Surgeon-in-Chief to the Metropolitan Police. Second Edition, thoroughly revised, with numerous Illustrations. 5 vols. 8vo. *£5 5s.*

The SURGICAL TREATMENT of CHILDREN'S DISEASES. By T. HOLMES, M.A. &c. late Surgeon to the Hospital for Sick Children. Second Edition, with 9 Plates and 112 Woodcuts. 8vo. *21s.*

LECTURES on the PRINCIPLES and PRACTICE of PHYSIC. By Sir THOMAS WATSON, Bart. M.D. New Edition in the press.

LECTURES on SURGICAL PATHOLOGY. By JAMES PAGET, F.R.S. Third Edition, revised and re-edited by the Author and Professor W. TURNER, M.B. 8vo. with 131 Woodcuts, *21s.*

COOPER'S DICTIONARY of PRACTICAL SURGERY and Encyclopædia of Surgical Science. New Edition, brought down to the present time. By S. A. LANE, Surgeon to St. Mary's Hospital, assisted by various Eminent Surgeons. VOL. II. 8vo. completing the work. [*In the press.*

On CHRONIC BRONCHITIS, especially as connected with GOUT, EMPHYSEMA, and DISEASES of the HEART. By E. HEADLAM GREENHOW, M.D. F.R.C.P. &c. 8vo. *7s. 6d.*

The CLIMATE of the SOUTH of FRANCE as SUITED to INVALIDS; with Notices of Mediterranean and other Winter Stations. By C. T. WILLIAMS, M.A. M.D. Oxon. Assistant-Physician to the Hospital for Consumption at Brompton. Second Edition, with Frontispiece and Map. Crown 8vo. *6s.*

REPORTS on the PROGRESS of PRACTICAL and SCIENTIFIC MEDICINE in Different Parts of the World, from June 1868, to June 1869. Edited by HORACE DOBELL, M.D. assisted by numerous and distinguished Coadjutors. 8vo. 18*s.*

PULMONARY CONSUMPTION; its Nature, Treatment, and Duration exemplified by an Analysis of One Thousand Cases selected from upwards of Twenty Thousand. By C. J. B. WILLIAMS, M.D. F.R.S. Consulting Physician to the Hospital for Consumption at Brompton; and C. T. WILLIAMS, M.A. M.D. Oxon. [*Nearly ready.*

CLINICAL LECTURES on DISEASES of the LIVER, JAUNDICE, and ABDOMINAL DROPSY. By CHARLES MURCHISON, M.D. Post 8vo. with 25 Woodcuts, 10*s.* 6*d.*

ANATOMY, DESCRIPTIVE and SURGICAL. By HENRY GRAY, F.R.S. With about 400 Woodcuts from Dissections. Fifth Edition, by T. HOLMES, M.A. Cantab. with a new Introduction by the Editor. Royal 8vo. 28*s.*

CLINICAL NOTES on DISEASES of the LARYNX, investigated and treated with the assistance of the Laryngoscope. By W. MARCET, M.D. F.R.S. Assistant-Physician to the Hospital for Consumption and Diseases of the Chest, Brompton. Crown 8vo. with 5 Lithographs, 6*s.*

The THEORY of OCULAR DEFECTS and of SPECTACLES. Translated from the German of Dr. H. SCHEFFLER by R. B. CARTER, F.R.C.S. With Prefatory Notes and a Chapter of Practical Instructions. Post 8vo. price 7*s.* 6*d.*

OUTLINES of PHYSIOLOGY, Human and Comparative. By JOHN MARSHALL, F.R.C.S. Surgeon to the University College Hospital. 2 vols. crown 8vo. with 122 Woodcuts, 32*s.*

ESSAYS on PHYSIOLOGICAL SUBJECTS. By GILBERT W. CHILD, M.A. Second Edition, revised, with Woodcuts. Crown 8vo. 7*s.* 6*d.*

PHYSIOLOGICAL ANATOMY and PHYSIOLOGY of MAN. By the late R. B. TODD, M.D. F.R.S. and W. BOWMAN, F.R.S. of King's College. With numerous Illustrations. VOL. II. 8vo. 25*s.*

VOL. I. New Edition by Dr. LIONEL S. BEALE, F.R.S. in course of publication; PART I. with 8 Plates, 7*s.* 6*d.*

COPLAND'S DICTIONARY of PRACTICAL MEDICINE, abridged from the larger work and throughout brought down to the present State of Medical Science. 8vo. 36*s.*

REIMANN'S HANDBOOK of ANILINE and its DERIVATIVES; a Treatise on the Manufacture of Aniline and Aniline Colours. Edited by WILLIAM CROOKES, F.R.S. With 5 Woodcuts. 8vo. 10*s.* 6*d.*

A MANUAL of MATERIA MEDICA and THERAPEUTICS, abridged from Dr. PEREIRA'S *Elements* by F. J. FARRE, M.D. assisted by R. BENTLEY, M.R.C.S. and by R. WARINGTON, F.R.S. 8vo. with 90 Woodcuts, 21*s.*

THOMSON'S CONSPECTUS of the BRITISH PHARMACOPŒIA. 25th Edition, corrected by E. LLOYD BIRKETT, M.D. 18mo. price 6*s.*

MANUAL of the DOMESTIC PRACTICE of MEDICINE. By W. B. KESTEVEN, F.R.C.S.E. Third Edition, revised, with Additions. Fcp. 5*s.*

GYMNASTS and GYMNASTICS. By JOHN H. HOWARD, late Professor of Gymnastics, Comm. Coll. Ripponden. Second Edition, revised and enlarged, with 135 Woodcuts. Crown 8vo. 10*s.* 6*d.*

The Fine Arts, and *Illustrated Editions.*

IN FAIRYLAND; Pictures from the Elf-World. By RICHARD DOYLE. With a Poem by W. ALLINGHAM. With Sixteen Plates, containing Thirty-six Designs printed in Colours. Folio, 31*s.* 6*d.*

LIFE of JOHN GIBSON, R.A. SCULPTOR. Edited by Lady EASTLAKE. 8vo. 10*s.* 6*d.*

The LORD'S PRAYER ILLUSTRATED by F. R. PICKERSGILL, R.A. and HENRY ALFORD, D.D. Dean of Canterbury. Imp. 4to. price 21*s.* cloth.

MATERIALS for a HISTORY of OIL PAINTING. By Sir CHARLES LOCKE EASTLAKE, sometime President of the Royal Academy. 2 vols. 8vo. price 30*s.*

HALF-HOUR LECTURES on the HISTORY and PRACTICE of the Fine and Ornamental Arts. By WILLIAM B. SCOTT. New Edition, revised by the Author; with 50 Woodcuts. Crown 8vo. 8*s.* 6*d.*

ALBERT DURER, HIS LIFE and WORKS; including Autobiographical Papers and Complete Catalogues. By WILLIAM B. SCOTT. With Six Etchings by the Author, and other Illustrations. 8vo. 16*s.*

SIX LECTURES on HARMONY, delivered at the Royal Institution of Great Britain in the Year 1867. By G. A. MACFARREN. With numerous engraved Musical Examples and Specimens. 8vo. 10*s.* 6*d.*

The CHORALE BOOK for ENGLAND: the Hymns translated by Miss C. WINKWORTH; the tunes arranged by Prof. W. S. BENNETT and OTTO GOLDSCHMIDT. Fcp. 4to. 12*s.* 6*d.*

The NEW TESTAMENT, illustrated with Wood Engravings after the Early Masters, chiefly of the Italian School. Crown 4to. 63*s.* cloth, gilt top; or £5 5*s.* elegantly bound in morocco.

LYRA GERMANICA; the Christian Year. Translated by CATHERINE WINKWORTH; with 125 Illustrations on Wood drawn by J. LEIGHTON, F.S.A. 4to. 21*s.*

LYRA GERMANICA; the Christian Life. Translated by CATHERINE WINKWORTH; with about 200 Woodcut Illustrations by J. LEIGHTON, F.S.A. and other Artists. 4to. 21*s.*

The LIFE of MAN SYMBOLISED by the MONTHS of the YEAR. Text selected by R. PIGOT; Illustrations on Wood from Original Designs by J. LEIGHTON, F.S.A. 4to. 42*s.*

CATS' and FARLIE'S MORAL EMBLEMS; with Aphorisms, Adages, and Proverbs of all Nations. 121 Illustrations on Wood by J. LEIGHTON, F.S.A. Text selected by R. PIGOT. Imperial 8vo. 31*s.* 6*d.*

SHAKSPEARE'S MIDSUMMER-NIGHT'S DREAM, illustrated with 24 Silhouettes or Shadow-Pictures by P. KONEWKA, engraved on Wood by A. VOGEL. Folio, 31*s.* 6*d.*

SHAKSPEARE'S SENTIMENTS and SIMILES, printed in Black and Gold, and Illuminated in the Missal Style by HENRY NOEL HUMPHREYS. Square post 8vo. 21*s.*

SACRED and LEGENDARY ART. By Mrs. JAMESON.

Legends of the Saints and Martyrs. Fifth Edition, with 19 Etchings and 187 Woodcuts. 2 vols. square crown 8vo. 31*s.* 6*d.*

Legends of the Monastic Orders. Third Edition, with 11 Etchings and 88 Woodcuts. 1 vol. square crown 8vo. 21*s.*

Legends of the Madonna. Third Edition, with 27 Etchings and 165 Woodcuts. 1 vol. square crown 8vo. 21*s.*

The History of Our Lord, with that of his Types and Precursors. Completed by Lady EASTLAKE. Revised Edition, with 31 Etchings and 281 Woodcuts. 2 vols. square crown 8vo. 42*s.*

The Useful Arts, Manufactures, &c.

HISTORY of the GOTHIC REVIVAL; an Attempt to shew how far the taste for Mediæval Architecture was retained in England during the last two centuries, and has been re-developed in the present. By CHARLES L. EASTLAKE, Architect. With many Illustrations. [*Nearly ready.*

GWILT'S ENCYCLOPÆDIA of ARCHITECTURE, with above 1,100 Engravings on Wood. Fifth Edition, revised and enlarged by WYATT PAPWORTH. Additionally illustrated with nearly 400 Wood Engravings by O. Jewitt, and more than 100 other new Woodcuts. 8vo. 52*s.* 6*d.*

ITALIAN SCULPTORS; being a History of Sculpture in Northern, Southern, and Eastern Italy. By C. C. PERKINS. With 30 Etchings and 13 Wood Engravings. Imperial 8vo. 42*s.*

TUSCAN SCULPTORS, their Lives, Works, and Times. With 45 Etchings and 28 Woodcuts from Original Drawings and Photographs. By the same Author. 2 vols. imperial 8vo. 63*s.*

HINTS on HOUSEHOLD TASTE in FURNITURE, UPHOLSTERY, and other Details. By CHARLES L. EASTLAKE, Architect. Second Edition, with about 90 Illustrations. Square crown 8vo. 12*s.*

The ENGINEER'S HANDBOOK; explaining the Principles which should guide the Young Engineer in the Construction of Machinery. By C. S. LOWNDES. Post 8vo. 5*s.*

PRINCIPLES of MECHANISM, designed for the Use of Students in the Universities, and for Engineering Students generally. By R. WILLIS, M.A. F.R.S. &c. Jacksonian Professor in the University of Cambridge. A new and enlarged Edition. 8vo. [*Nearly ready.*

LATHES and TURNING, Simple, Mechanical, and ORNAMENTAL. By W. HENRY NORTHCOTT. With about 240 Illustrations on Steel and Wood. 8vo. 18*s.*

URE'S DICTIONARY of ARTS, MANUFACTURES, and MINES. Sixth Edition, chiefly rewritten and greatly enlarged by ROBERT HUNT, F.R.S. assisted by numerous Contributors eminent in Science and the Arts, and familiar with Manufactures. With above 2,000 Woodcuts. 3 vols. medium 8vo. price £4 14*s.* 6*d.*

HANDBOOK of PRACTICAL TELEGRAPHY, published with the sanction of the Chairman and Directors of the Electric and International Telegraph Company, and adopted by the Department of Telegraphs for India. By R. S. CULLEY. Third Edition. 8vo. 12*s.* 6*d.*

ENCYCLOPÆDIA of CIVIL ENGINEERING, Historical, Theoretical, and Practical. By E. CRESY, C.E. With above 3,000 Woodcuts. 8vo. 42*s.*

TREATISE on MILLS and MILLWORK. By Sir W. FAIRBAIRN, F.R.S. Second Edition, with 18 Plates and 322 Woodcuts. 2 vols. 8vo. 32*s.*

USEFUL INFORMATION for ENGINEERS. By the same Author. FIRST, SECOND, and THIRD SERIES, with many Plates and Woodcuts. 3 vols. crown 8vo. 10*s.* 6*d.* each.

The APPLICATION of CAST and WROUGHT IRON to Building Purposes. By the same Author. Fourth Edition, enlarged; with 6 Plates and 118 Woodcuts. 8vo. price 16*s.*

IRON SHIP BUILDING, its History and Progress, as comprised in a Series of Experimental Researches. By the same Author. With 4 Plates and 130 Woodcuts. 8vo. 18*s.*

A TREATISE on the STEAM ENGINE, in its various Applications to Mines, Mills, Steam Navigation, Railways and Agriculture. By J. BOURNE, C.E. Eighth Edition; with Portrait, 37 Plates, and 546 Woodcuts. 4to. 42*s.*

CATECHISM of the STEAM ENGINE, in its various Applications to Mines, Mills, Steam Navigation, Railways, and Agriculture. By the same Author. With 89 Woodcuts. Fcp. 6*s.*

HANDBOOK of the STEAM ENGINE. By the same Author, forming a KEY to the Catechism of the Steam Engine, with 67 Woodcuts. Fcp. 9*s.*

BOURNE'S RECENT IMPROVEMENTS in the STEAM ENGINE in its various applications to Mines, Mills, Steam Navigation, Railways, and Agriculture. Being a Supplement to the Author's 'Catechism of the Steam Engine.' By JOHN BOURNE, C.E. New Edition, including many New Examples; with 124 Woodcuts. Fcp. 8vo. 6*s.*

A TREATISE on the SCREW PROPELLER, SCREW VESSELS, and Screw Engines, as adapted for purposes of Peace and War; with Notices of other Methods of Propulsion, Tables of the Dimensions and Performance of Screw Steamers, and detailed Specifications of Ships and Engines. By J. BOURNE, C.E. New Edition, with 54 Plates and 287 Woodcuts. 4to. 63*s.*

EXAMPLES of MODERN STEAM, AIR, and GAS ENGINES of the most Approved Types, as employed for Pumping, for Driving Machinery, for Locomotion, and for Agriculture, minutely and practically described. By JOHN BOURNE, C.E. In course of publication in 24 Parts, price 2*s.* 6*d.* each, forming One volume 4to. with about 50 Plates and 400 Woodcuts.

A HISTORY of the MACHINE-WROUGHT HOSIERY and LACE Manufactures. By WILLIAM FELKIN, F.L.S. F.S.S. Royal 8vo. 21*s.*

PRACTICAL TREATISE on METALLURGY, adapted from the last German Edition of Professor KERL'S *Metallurgy* by W. CROOKES, F.R.S. &c. and E. RÖHRIG, Ph.D. M.E. In Three Volumes, 8vo. with 625 Woodcuts. VOL. I. price 31*s.* 6*d.* VOL. II. price 36*s.* VOL. III. price 31*s.* 6*d.*

MITCHELL'S MANUAL of PRACTICAL ASSAYING. Third Edition, for the most part re-written, with all the recent Discoveries incorporated, by W. CROOKES, F.R.S. With 188 Woodcuts. 8vo. 28*s.*

The ART of PERFUMERY; the History and Theory of Odours, and the Methods of Extracting the Aromas of Plants. By Dr. PIESSE, F.C.S. Third Edition, with 53 Woodcuts. Crown 8vo. 10*s.* 6*d.*

Chemical, Natural, and Physical Magic, for Juveniles during the Holidays. By the same Author. Third Edition, with 38 Woodcuts. Fcp. 6*s.*

LOUDON'S ENCYCLOPÆDIA of AGRICULTURE: comprising the Laying-out, Improvement, and Management of Landed Property, and the Cultivation and Economy of the Productions of Agriculture. With 1,100 Woodcuts. 8vo. 21*s.*

Loudon's Encyclopædia of Gardening: comprising the Theory and Practice of Horticulture, Floriculture, Arboriculture, and Landscape Gardening. With 1,000 Woodcuts. 8vo. 21*s.*

BAYLDON'S ART of VALUING RENTS and TILLAGES, and Claims of Tenants upon Quitting Farms, both at Michaelmas and Lady-Day. Eighth Edition, revised by J. C. MORTON. 8vo. 10*s.* 6*d.*

Religious and *Moral Works.*

CONSIDERATIONS on the REVISION of the ENGLISH NEW TESTAMENT. By C. J. ELLICOTT, D.D. Lord Bishop of Gloucester and Bristol. Post 8vo. price 5*s.* 6*d.*

An EXPOSITION of the 39 ARTICLES, Historical and Doctrinal. By E. HAROLD BROWNE, D.D. Lord Bishop of Ely. Seventh Edit. 8vo. 16*s.*

BISHOP COTTON'S INSTRUCTIONS in the PRINCIPLES and Practice of Christianity, intended chiefly as an introduction to Confirmation. Sixth Edition, 18mo. 2*s.* 6*d.*

The ACTS of the APOSTLES; with a Commentary, and Practical and Devotional Suggestions for Readers and Students of the English Bible. By the Rev. F. C. COOK, M.A. Canon of Exeter, &c. New Edition. 8vo. 12*s.* 6*d.*

The LIFE and EPISTLES of ST. PAUL. By the Rev. W. J. CONYBEARE, M.A., and the Very Rev. J. S. HOWSON, D.D. Dean of Chester:—

LIBRARY EDITION, with all the Original Illustrations, Maps, Landscapes on Steel, Woodcuts, &c. 2 vols. 4to. 48*s.*

INTERMEDIATE EDITION, with a Selection of Maps, Plates, and Woodcuts. 2 vols. square crown 8vo. 31*s.* 6*d.*

STUDENT'S EDITION, revised and condensed, with 46 Illustrations and Maps. 1 vol. crown 8vo. price 9*s.*

The VOYAGE and SHIPWRECK of ST. PAUL; with Dissertations on the Life and Writings of St. Luke and the Ships and Navigation of the Ancients. By JAMES SMITH, F.R.S. Third Edition. Crown 8vo. 10*s.* 6*d.*

A CRITICAL and GRAMMATICAL COMMENTARY on ST. PAUL'S Epistles. By C. J. ELLICOTT, D.D. Lord Bishop of Gloucester & Bristol. 8vo.

Galatians, Fourth Edition, 8*s.* 6*d.*

Ephesians, Fourth Edition, 8*s.* 6*d.*

Pastoral Epistles, Fourth Edition, 10*s.* 6*d.*

Philippians, Colossians, and Philemon, Third Edition, 10*s.* 6*d.*

Thessalonians, Third Edition, 7*s.* 6*d.*

HISTORICAL LECTURES on the LIFE of OUR LORD JESUS CHRIST: being the Hulsean Lectures for 1859. By C. J. ELLICOTT, D.D. Lord Bishop of Gloucester and Bristol. Fifth Edition. 8vo. price 12*s.*

EVIDENCE of the TRUTH of the CHRISTIAN RELIGION derived from the Literal Fulfilment of Prophecy. By ALEXANDER KEITH, D.D. 37th Edition, with numerous Plates, in square 8vo. 12*s.* 6*d.*; also the 39th Edition, in post 8vo. with 5 Plates, 6*s.*

History and Destiny of the World and Church, according to Scripture. By the same Author. Square 8vo. with 40 Illustrations, 10*s.*

An INTRODUCTION to the STUDY of the NEW TESTAMENT, Critical, Exegetical, and Theological. By the Rev. S. DAVIDSON, D.D. LL.D. 2 vols. 8vo. 30*s.*

Rev. T. H. HORNE'S INTRODUCTION to the CRITICAL STUDY and Knowledge of the Holy Scriptures. Twelfth Edition, as last revised throughout. With 4 Maps and 22 Woodcuts and Facsimiles. 4 vols. 8vo. 42*s.*

Rev. T. H. Horne's Compendious Introduction to the Study of the Bible, being an Analysis of the larger work by the same Author. Re-edited by the Rev. JOHN AYRE, M.A. With Maps, &c. Post 8vo. 6*s.*

HISTORY of the KARAITE JEWS. By WILLIAM HARRIS RULE, D.D. Post 8vo. price 7*s.* 6*d.*

EWALD'S HISTORY of ISRAEL to the DEATH of MOSES. Translated from the German. Edited, with a Preface and an Appendix, by RUSSELL MARTINEAU, M.A. Second Edition. 2 vols. 8vo. 24*s.*

FIVE YEARS in a PROTESTANT SISTERHOOD and TEN YEARS in a Catholic Convent; an Autobiography. Post 8vo. 7*s.* 6*d.*

The LIFE of MARGARET MARY HALLAHAN, better known in the religious world by the name of Mother Margaret. By her RELIGIOUS CHILDREN. Second Edition. 8vo. with Portrait, 10*s.*

The SEE of ROME in the MIDDLE AGES. By the Rev. OSWALD J. REICHEL, B.C.L. and M.A. 8vo. price 18*s.*

The EVIDENCE for the PAPACY, as derived from the Holy Scriptures and from Primitive Antiquity; with an Introductory Epistle. By the Hon. COLIN LINDSAY. 8vo. price 12*s.* 6*d.*

The TREASURY of BIBLE KNOWLEDGE; being a Dictionary of the Books, Persons, Places, Events, and other matters of which mention is made in Holy Scripture. By Rev. J. AYRE, M.A. With Maps, 16 Plates, and numerous Woodcuts. Fcp. 8vo price 6*s.* cloth, or 9*s.* 6*d.* neatly bound in calf.

The GREEK TESTAMENT; with Notes, Grammatical and Exegetical. By the Rev. W. WEBSTER, M.A. and the Rev. W. F. WILKINSON, M.A. 2 vols. 8vo. £2 4*s.*

EVERY-DAY SCRIPTURE DIFFICULTIES explained and illustrated. By J. E. PRESCOTT, M.A. VOL. I. *Matthew* and *Mark*; VOL. II. *Luke* and *John*. 2 vols. 8vo. 9*s.* each.

The PENTATEUCH and BOOK of JOSHUA CRITICALLY EXAMINED. By the Right Rev. J. W. COLENSO, D.D. Lord Bishop of Natal. People's Edition, in 1 vol. crown 8vo. 6*s.* or in 5 Parts, 1*s.* each.

The CHURCH and the WORLD; Three Series of Essays on Questions of the Day. By Various Writers. Edited by the Rev. ORBY SHIPLEY, M.A. Three Volumes, 8vo. price 15*s.* each.

The FORMATION of CHRISTENDOM. By T. W. ALLIES. PARTS I. and II. 8vo. price 12*s.* each Part.

ENGLAND and CHRISTENDOM. By ARCHBISHOP MANNING, D.D. Post 8vo. price 10*s.* 6*d.*

CHRISTENDOM'S DIVISIONS, PART I., a Philosophical Sketch of the Divisions of the Christian Family in East and West. By EDMUND S. FFOULKES. Post 8vo. price 7*s.* 6*d.*

Christendom's Divisions, PART II. Greeks and Latins, being a History of their Dissensions and Overtures for Peace down to the Reformation. By the same Author. Post 8vo. 15*s.*

The HIDDEN WISDOM of CHRIST and the KEY of KNOWLEDGE; or, History of the Apocrypha. By ERNEST DE BUNSEN. 2 vols. 8vo. 28*s.*

The KEYS of ST. PETER; or, the House of Rechab, connected with the History of Symbolism and Idolatry. By the same Author. 8vo. 14*s.*

The TYPES of GENESIS, briefly considered as Revealing the Development of Human Nature. By ANDREW JUKES. Second Edition. Crown 8vo. 7*s.* 6*d.*

The Second Death and the Restitution of All Things, with some Preliminary Remarks on the Nature and Inspiration of Holy Scripture. By the same Author. Second Edition. Crown 8vo. 3*s.* 6*d.*

A VIEW of the SCRIPTURE REVELATIONS CONCERNING a FUTURE STATE. By RICHARD WHATELY, D.D. late Archbishop of Dublin. Ninth Edition. Fcp. 8vo. 5*s.*

The POWER of the SOUL over the BODY. By GEORGE MOORE, M.D. M.R.C.P.L. &c. Sixth Edition. Crown 8vo. 8*s.* 6*d.*

THOUGHTS for the AGE. By ELIZABETH M. SEWELL, Author of 'Amy Herbert' &c. Fcp. 8vo. price 5*s.*

Passing Thoughts on Religion. By the same Author. Fcp. 8vo. 5*s.*

Self-Examination before Confirmation. By the same Author. 32mo. price 1*s.* 6*d.*

Readings for a Month Preparatory to Confirmation, from Writers of the Early and English Church. By the same Author. Fcp. 4*s.*

Readings for Every Day in Lent, compiled from the Writings of Bishop JEREMY TAYLOR. By the same Author. Fcp. 5*s.*

Preparation for the Holy Communion; the Devotions chiefly from the works of JEREMY TAYLOR. By the same Author. 32mo. 3*s.*

THOUGHTS for the HOLY WEEK for Young Persons. By the Author of 'Amy Herbert.' New Edition. Fcp. 8vo. 2*s.*

PRINCIPLES of EDUCATION Drawn from Nature and Revelation, and applied to Female Education in the Upper Classes. By the Author of 'Amy Herbert.' 2 vols. fcp. 12*s.* 6*d.*

The WIFE'S MANUAL; or, Prayers, Thoughts, and Songs on Several Occasions of a Matron's Life. By the Rev. W. CALVERT, M.A. Crown 8vo. price 10*s.* 6*d.*

SINGERS and SONGS of the CHURCH: being Biographical Sketches of the Hymn-Writers in all the principal Collections; with Notes on their Psalms and Hymns. By JOSIAH MILLER, M.A. Second Edition, enlarged. Post 8vo. price 10*s.* 6*d.*

LYRA GERMANICA, translated from the German by Miss C. WINKWORTH. FIRST SERIES, Hymns for the Sundays and Chief Festivals SECOND SERIES, the Christian Life. Fcp. 3*s.* 6*d.* each SERIES.

'SPIRITUAL SONGS' for the SUNDAYS and HOLIDAYS throughout the Year. By J. S. B. MONSELL, LL.D. Vicar of Egham and Rural Dean. Fourth Edition, Sixth Thousand. Fcp. 4s. 6d.

The BEATITUDES: Abasement before God; Sorrow for Sin; Meekness of Spirit; Desire for Holiness; Gentleness; Purity of Heart; the Peacemakers; Sufferings for Christ. By the same. Third Edition. Fcp. 3s. 6d.

His PRESENCE—not his MEMORY, 1855. By the same Author, in Memory of his SON. Sixth Edition. 16mo. 1s.

LYRA EUCHARISTICA; Hymns and Verses on the Holy Communion, Ancient and Modern: with other Poems. Edited by the Rev. ORBY SHIPLEY, M.A. Second Edition. Fcp. 5s.

Lyra Messianica; Hymns and Verses on the Life of Christ, Ancient and Modern; with other Poems. By the same Editor. Second Edition, altered and enlarged. Fcp. 5s.

Lyra Mystica; Hymns and Verses on Sacred Subjects, Ancient and Modern. By the same Editor. Fcp. 5s.

ENDEAVOURS after the CHRISTIAN LIFE: Discourses. By JAMES MARTINEAU. Fourth and cheaper Edition, carefully revised; the Two Series complete in One Volume. Post 8vo. 7s. 6d.

INVOCATION of SAINTS and ANGELS, for the use of Members of the English Church. Edited by the Rev. ORBY SHIPLEY. 24mo. 3s. 6d.

WHATELY'S INTRODUCTORY LESSONS on the CHRISTIAN Evidences. 18mo. 6d.

WHATELY'S INTRODUCTORY LESSONS on the HISTORY of Religious Worship. New Edition. 18mo. 2s. 6d.

BISHOP JEREMY TAYLOR'S ENTIRE WORKS. With Life by BISHOP HEBER. Revised and corrected by the Rev. C. P. EDEN, 10 vols. price £5 5s.

Travels, Voyages, &c.

NARRATIVE of a SPRING TOUR in PORTUGAL. By A. C. SMITH, M.A. Ch. Ch. Oxon. Rector of Yatesbury. Post 8vo. price 6s. 6d.

ENGLAND to DELHI; a Narrative of Indian Travel. By JOHN MATHESON, Glasgow. With Map and 82 Woodcut Illustrations. 4to. 31s. 6d.

CADORE; or, **TITIAN'S COUNTRY.** By JOSIAH GILBERT, one of the Authors of 'The Dolomite Mountains.' With Map, Facsimile, and 40 Illustrations. Imperial 8vo. 31s. 6d.

NARRATIVE of the EUPHRATES EXPEDITION carried on by Order of the British Government during the years 1835–1837. By General F. R. CHESNEY, F.R.S. With Maps, Plates, and Woodcuts. 8vo. 24s.

TRAVELS in the CENTRAL CAUCASUS and BASHAN. Including Visits to Ararat and Tabreez and Ascents of Kazbek and Elbruz. By D. W. FRESHFIELD. Square crown 8vo. with Maps, &c. 18s.

PICTURES in TYROL and Elsewhere. From a Family Sketch-Book. By the Authoress of 'A Voyage en Zigzag,' &c. Second Edition. Small 4to. with numerous Illustrations, 21s.

HOW WE SPENT the SUMMER; or, a Voyage en Zigzag in Switzerland and Tyrol with some Members of the ALPINE CLUB. From the Sketch-Book of one of the Party. In oblong 4to. with 300 Illustrations, 15s.

BEATEN TRACKS; or, Pen and Pencil Sketches in Italy. By the Authoress of 'A Voyage en Zigzag.' With 42 Plates, containing about 200 Sketches from Drawings made on the Spot. 8vo. 16*s.*

MAP of the CHAIN of MONT BLANC, from an actual Survey in 1863—1864. By A. ADAMS-REILLY, F.R.G.S. M.A.C. Published under the Authority of the Alpine Club. In Chromolithography on extra stout drawing-paper 28in. × 17in. price 10*s.* or mounted on canvas in a folding case, 12*s.* 6*d.*

WESTWARD by RAIL; the New Route to the East. By W. F. RAE. With Map shewing the Lines of Rail between the Atlantic and the Pacific, and Sections of the Railway. Post 8vo. price 10*s.* 6*d.*

The PARAGUAYAN WAR: with Sketches of the History of Paraguay, and of the Manners and Customs of the People; and Notes on the Military Engineering of the War. By GEORGE THOMPSON, C.E. With 8 Maps and Plans, and a Portrait of Lopez. Post 8vo. 12*s.* 6*d.*

HISTORY of DISCOVERY in our AUSTRALASIAN COLONIES, Australia, Tasmania, and New Zealand, from the Earliest Date to the Present Day. By WILLIAM HOWITT. 2 vols. 8vo. with 3 Maps, 20*s.*

NOTES on BURGUNDY. By CHARLES RICHARD WELD. Edited by his Widow; with Portrait and Memoir. Post 8vo. 8*s.* 6*d.*

The CAPITAL of the TYCOON; a Narrative of a Three Years' Residence in Japan. By Sir RUTHERFORD ALCOCK, K.C.B. 2 vols. 8vo. with numerous Illustrations, 42*s.*

The DOLOMITE MOUNTAINS; Excursions through Tyrol, Carinthia, Carniola, and Friuli, 1861-1863. By J. GILBERT and G. C. CHURCHILL, F.R.G.S. With numerous Illustrations. Square crown 8vo. 21*s.*

GUIDE to the PYRENEES, for the use of Mountaineers. By CHARLES PACKE. 2nd Edition, with Map and Illustrations. Cr. 8vo. 7*s.* 6*d.*

The ALPINE GUIDE. By JOHN BALL, M.R.I.A. late President of the Alpine Club. Thoroughly Revised Editions, in Three Volumes, post 8vo. with Maps and other Illustrations:—

GUIDE to the WESTERN ALPS, including Mont Blanc, Monte Rosa, Zermatt, &c. Price 6*s.* 6*d.*

GUIDE to the CENTRAL ALPS, including all the Oberland District. 7*s.* 6*d.*

GUIDE to the EASTERN ALPS, price 10*s.* 6*d.*

Introduction on Alpine Travelling in General, and on the Geology of the Alps, price 1*s.* Each of the Three Volumes or Parts of the *Alpine Guide* may be had with this INTRODUCTION prefixed, price 1*s.* extra.

The HIGH ALPS WITHOUT GUIDES. By the Rev. A. G. GIRDLESTONE, M.A. late Demy in Natural Science, Magdalen College, Oxford. With Frontispiece and 2 Maps. Square crown 8vo. price 7*s.* 6*d.*

MEMORIALS of LONDON and LONDON LIFE in the 13th, 14th, and 15th Centuries; being a Series of Extracts, Local, Social, and Political, from the Archives of the City of London, A.D. 1276-1419. Selected, translated, and edited by H. T. RILEY, M.A. Royal 8vo. 21*s.*

COMMENTARIES on the HISTORY, CONSTITUTION, and CHARTERED FRANCHISES of the CITY of LONDON. By GEORGE NORTON, formerly one of the Common Pleaders of the City of London. Third Edition. 8vo. 14*s.*

The NORTHERN HEIGHTS of LONDON; or, Historical Associations of Hampstead, Highgate, Muswell Hill, Hornsey, and Islington. By WILLIAM HOWITT. With about 40 Woodcuts. Square crown 8vo. 21*s.*

VISITS to REMARKABLE PLACES: Old Halls, Battle-Fields, and Stones Illustrative of Striking Passages in English History and Poetry. By WILLIAM HOWITT. 2 vols. square crown 8vo. with Woodcuts, 25*s.*

The RURAL LIFE of ENGLAND. By the same Author. With Woodcuts by Bewick and Williams. Medium 8vo. 12*s.* 6*d.*

ROMA SOTTERRANEA; or, an Account of the Roman Catacombs, especially of the Cemetery of San Callisto. Compiled from the Works of Commendatore G. B. DE ROSSI by the Rev. J. S. NORTHCOTE, D.D. and the Rev. W. B. BROWNLOW. With numerous Illustrations. 8vo. 31*s.* 6*d.*

PILGRIMAGES in the PYRENEES and LANDES. By DENYS SHYNE LAWLOR. Crown 8vo. with Frontispiece and Vignette, price 15*s.*

The GERMAN WORKING MAN; being an Account of the Daily Life, Amusements, and Unions for Culture and Material Progress of the Artisans of North and South Germany and Switzerland. By JAMES SAMUELSON. Crown 8vo. with Frontispiece, 3*s.* 6*d.*

Works of *Fiction.*

LOTHAIR. By the Right Hon. B. DISRAELI, M.P. Seventh Edition. 3 vols. post 8vo. price 31*s.* 6*d.*

Nôsse omnia hæc, salus est adolescentulis.—TERENTIUS.

NO APPEAL; a Novel. By the Author of 'Cut down like Grass.' 3 vols. post 8vo. price 31*s.* 6*d.*

The MODERN NOVELIST'S LIBRARY. Each Work, in crown 8vo. complete in a Single Volume:—

MELVILLE'S GLADIATORS, 2*s.* boards; 2*s.* 6*d.* cloth.
———— HOLMBY HOUSE, 2*s.* boards; 2*s.* 6*d.* cloth.
———— INTERPRETER, 2*s.* boards; 2*s.* 6*d.* cloth.
TROLLOPE'S WARDEN, 1*s.* 6*d.* boards; 2*s.* cloth.
———— BARCHESTER TOWERS, 2*s.* boards; 2*s.* 6*d.* cloth.
BRAMLEY-MOORE'S SIX SISTERS OF THE VALLEYS, 2*s.* boards; 2*s.* 6*d.* cloth.

THREE WEDDINGS. By the Author of 'Dorothy,' 'De Cressy,' &c. Fcp. 8vo. price 5*s.*

STORIES and TALES by ELIZABETH M. SEWELL, Author of 'Amy Herbert,' uniform Edition, each *Story* or *Tale* complete in a single Volume:

AMY HERBERT, 2*s.* 6*d.*	IVORS, 3*s.* 6*d.*
GERTRUDE, 2*s.* 6*d.*	KATHARINE ASHTON, 3*s.* 6*d.*
EARL'S DAUGHTER, 2*s.* 6*d.*	MARGARET PERCIVAL, 5*s.*
EXPERIENCE OF LIFE, 2*s.* 6*d.*	LANETON PARSONAGE, 4*s.* 6*d.*
CLEVE HALL, 3*s.* 6*d.*	URSULA, 4*s.* 6*d.*

A Glimpse of the World. By the Author of 'Amy Herbert.' Fcp. 7*s.* 6*d.*

The Journal of a Home Life. By the same Author. Post 8vo. 9*s.* 6*d.*

After Life; a Sequel to 'The Journal of a Home Life.' Price 10*s.* 6*d.*

UNCLE PETER'S FAIRY TALE for the XIX CENTURY. Edited by E. M. SEWELL, Author of 'Amy Herbert,' &c. Fcp. 8vo. 7*s.* 6*d.*

VIKRAM and the VAMPIRE; or, Tales of Hindu Devilry. Adapted by RICHARD F. BURTON, F.R.G.S. &c. With 33 Illustrations by Ernest Griset. Crown 8vo. 9*s.*

THROUGH the NIGHT; a Tale of the Times. To which is added 'Onward, or a Summer Sketch.' By WALTER SWEETMAN, B.A. 2 vols. post 8vo. 21*s.*

BECKER'S GALLUS; or, Roman Scenes of the Time of Augustus: with Notes and Excursuses. New Edition. Post 8vo. 7*s.* 6*d.*

BECKER'S CHARICLES; a Tale illustrative of Private Life among the Ancient Greeks: with Notes and Excursuses. New Edition. Post 8vo. 7*s.* 6*d.*

NOVELS and TALES by G. J. WHYTE MELVILLE :—

The GLADIATORS, 5*s.*	HOLMBY HOUSE, 5*s.*
DIGBY GRAND, 5*s.*	GOOD for NOTHING, 6*s.*
KATE COVENTRY, 5*s.*	The QUEEN'S MARIES, 6*s.*
GENERAL BOUNCE, 5*s.*	The INTERPRETER, 5*s.*

TALES of ANCIENT GREECE. By GEORGE W. COX, M.A. late Scholar of Trin. Coll. Oxon. Being a Collective Edition of the Author's Classical Stories and Tales, complete in One Volume. Crown 8vo. 6*s.* 6*d.*

A MANUAL of MYTHOLOGY, in the form of Question and Answer. By the same Author. Fcp. 3*s.*

OUR CHILDREN'S STORY, by one of their Gossips. By the Author of 'Voyage en Zigzag,' 'Pictures in Tyrol,' &c. Small 4to. with Sixty Illustrations by the Author, price 10*s.* 6*d.*

Poetry and *The Drama.*

THOMAS MOORE'S POETICAL WORKS, the only Editions containing the Author's last Copyright Additions :—

CABINET EDITION, 10 vols. fcp. 8vo. price 35*s.*
SHAMROCK EDITION, crown 8vo. price 3*s.* 6*d.*
RUBY EDITION, crown 8vo. with Portrait, price 6*s.*
LIBRARY EDITION, medium 8vo. Portrait and Vignette, 14*s.*
PEOPLE'S EDITION, square crown 8vo. with Portrait, &c. 10*s.* 6*d.*

MOORE'S IRISH MELODIES, Maclise's Edition, with 161 Steel Plates from Original Drawings. Super-royal 8vo. 31*s.* 6*d.*

Miniature Edition of Moore's Irish Melodies with Maclise's Designs (as above) reduced in Lithography. Imp. 16mo. 10*s.* 6*d.*

MOORE'S LALLA ROOKH. Tenniel's Edition, with 68 Wood Engravings from original Drawings and other Illustrations. Fcp. 4to. 21*s.*

SOUTHEY'S POETICAL WORKS, with the Author's last Corrections and copyright Additions. Library Edition, in 1 vol. medium 8vo. with Portrait and Vignette, 14*s.*

LAYS of ANCIENT ROME; with *Ivry* and the *Armada.* By the Right Hon. LORD MACAULAY. 16mo. 4*s.* 6*d.*

Lord Macaulay's Lays of Ancient Rome. With 90 Illustrations on Wood, from the Antique, from Drawings by G. SCHARF. Fcp. 4to. 21*s.*

Miniature Edition of Lord Macaulay's Lays of Ancient Rome, with the Illustrations (as above) reduced in Lithography. Imp. 16mo. 10*s.* 6*d.*

GOLDSMITH'S POETICAL WORKS, with Wood Engravings from Designs by Members of the ETCHING CLUB. Imperial 16mo. 7*s.* 6*d.*

POEMS. By JEAN INGELOW. Fifteenth Edition. Fcp. 8vo. 5*s.*

POEMS by Jean Ingelow. With nearly 100 Illustrations by Eminent Artists, engraved on Wood by the Brothers DALZIEL. Fcp. 4to. 21*s.*

MOPSA the FAIRY. By JEAN INGELOW. Pp. 256, with Eight Illustrations engraved on Wood. Fcp. 8vo. 6*s.*

A STORY of DOOM, and other Poems. By JEAN INGELOW. Third Edition. Fcp. 5*s.*

POETICAL WORKS of LETITIA ELIZABETH LANDON (L.E.L.). 2 vols. 16mo. 10*s.*

GLAPHYRA, and OTHER POEMS By FRANCIS REYNOLDS, Author of 'Alice Rushton, and other Poems.' 16mo. price 5*s.*

BOWDLER'S FAMILY SHAKSPEARE, cheaper Genuine Editions: Medium 8vo. large type, with 36 Woodcuts, price 14*s.* Cabinet Edition, with the same ILLUSTRATIONS, 6 vols. fcp. 3*s.* 6*d.* each.

HORATII OPERA, Pocket Edition, with carefully corrected Text, Marginal References, and Introduction. Edited by the Rev. J. E. YONGE, M.A. Square 18mo. 4*s.* 6*d.*

HORATII OPERA. Library Edition, with Marginal References and English Notes. Edited by the Rev. J. E. YONGE. 8vo. 21*s.*

The ÆNEID of VIRGIL Translated into English Verse. By JOHN CONINGTON, M.A. New Edition. Crown 8vo. 9*s.*

ARUNDINES CAMI, sive Musarum Cantabrigiensium Lusus canori. Collegit atque edidit H. DRURY, M.A. Editio Sexta, curavit H. J. HODGSON, M.A. Crown 8vo. 7*s.* 6*d.*

HUNTING SONGS and MISCELLANEOUS VERSES. By R. E. EGERTON WARBURTON. Second Edition. Fcp. 8vo. 5*s.*

The SILVER STORE collected from Mediæval Christian and Jewish Mines. By the Rev. SABINE BARING-GOULD, M.A. Crown 8vo. 3*s.* 6*d.*

Rural Sports, &c.

ENCYCLOPÆDIA of RURAL SPORTS; a complete Account, Historical, Practical, and Descriptive, of Hunting, Shooting, Fishing, Racing, and all other Rural and Athletic Sports and Pastimes. By D. P. BLAINE. With above 600 Woodcuts (20 from Designs by JOHN LEECH). 8vo. 21*s.*

Col. HAWKER'S INSTRUCTIONS to YOUNG SPORTSMEN in all that relates to Guns and Shooting. Revised by the Author's SON. Square crown 8vo. with Illustrations, 18*s.*

The DEAD SHOT, or Sportsman's Complete Guide; a Treatise on the Use of the Gun, Dog-breaking, Pigeon-shooting, &c. By MARKSMAN. Revised Edition. Fcp. 8vo. with Plates, 5*s.*

The FLY-FISHER'S ENTOMOLOGY. By ALFRED RONALDS. With coloured Representations of the Natural and Artificial Insect. Sixth Edition; with 20 coloured Plates. 8vo. 14*s.*

A BOOK on ANGLING; a complete Treatise on the Art of Angling in every branch. By FRANCIS FRANCIS. Second Edition, with Portrait and 15 other Plates, plain and coloured. Post 8vo. 15*s.*

The BOOK of the ROACH. By GREVILLE FENNELL, of 'The Field.' Fcp. 8vo. price 2*s.* 6*d.*

WILCOCKS'S SEA-FISHERMAN; comprising the Chief Methods of Hook and Line Fishing in the British and other Seas, a Glance at Nets, and Remarks on Boats and Boating. Second Edition, enlarged; with 80 Woodcuts. Post 8vo. 12*s.* 6*d.*

HORSES and STABLES. By Colonel F. FITZWYGRAM, XV. the King's Hussars. With Twenty-four Plates of Illustrations, containing very numerous Figures engraved on Wood. 8vo. 15*s.*

The HORSE'S FOOT, and HOW to KEEP IT SOUND. By W. MILES, Esq. Ninth Edition, with Illustrations. Imperial 8vo. 12*s.* 6*d.*

A PLAIN TREATISE on HORSE-SHOEING. By the same Author. Sixth Edition. Post 8vo. with Illustrations, 2*s.* 6*d.*

STABLES and STABLE-FITTINGS. By the same. Imp. 8vo. with 13 Plates, 15*s.*

REMARKS on HORSES' TEETH, addressed to Purchasers. By the same. Post 8vo. 1*s.* 6*d.*

ROBBINS'S CAVALRY CATECHISM, or Instructions on Cavalry Exercise and Field Movements, Brigade Movements, Out-post Duty, Cavalry supporting Artillery, Artillery attached to Cavalry. 12mo. 5*s.*

BLAINE'S VETERINARY ART; a Treatise on the Anatomy, Physiology, and Curative Treatment of the Diseases of the Horse, Neat Cattle and Sheep. Seventh Edition, revised and enlarged by C. STEEL, M.R.C.V.S.L. 8vo. with Plates and Woodcuts, 18*s.*

The HORSE: with a Treatise on Draught. By WILLIAM YOUATT. New Edition, revised and enlarged. 8vo. with numerous Woodcuts, 12*s.* 6*d.*

The Dog. By the same Author. 8vo. with numerous Woodcuts, 6*s.*

The DOG in HEALTH and DISEASE. By STONEHENGE. With 70 Wood Engravings. Square crown 8vo. 10*s.* 6*d.*

The GREYHOUND. By STONEHENGE. Revised Edition, with 24 Portraits of Greyhounds. Square crown 8vo. 10*s.* 6*d.*

The OX; his Diseases and their Treatment: with an Essay on Parturition in the Cow. By J. R. DOBSON. Crown 8vo. with Illustrations, 7*s.* 6*d.*

Commerce, Navigation, and *Mercantile Affairs.*

The ELEMENTS of BANKING. By HENRY DUNNING MACLEOD, M.A. Barrister-at-Law. Post 8vo. [*Nearly ready.*

The THEORY and PRACTICE of BANKING. By the same Author. Second Edition, entirely remodelled. 2 vols. 8vo. 30*s.*

PRACTICAL GUIDE for BRITISH SHIPMASTERS to UNITED States Ports. By PIERREPONT EDWARDS. Post 8vo. 8*s.* 6*d.*

A DICTIONARY, Practical, Theoretical, and Historical, of Commerce and Commercial Navigation. By J. R. M'CULLOCH, Esq. New and thoroughly revised Edition. 8vo. price 63*s.* cloth, or 70*s.* half-bd. in russia.

The LAW of NATIONS Considered as Independent Political Communities. By Sir TRAVERS TWISS, D.C.L. 2 vols. 8vo. 30*s.*, or separately, PART I. *Peace,* 12*s.* PART II. *War,* 18*s.*

Works of *Utility* and *General Information.*

The CABINET LAWYER; a Popular Digest of the Laws of England, Civil, Criminal, and Constitutional. Twenty-fifth Edition, brought down to the close of the Parliamentary Session of 1869. Fcp. 10*s.* 6*d.*

PEWTNER'S COMPREHENSIVE SPECIFIER; A Guide to the Practical Specification of every kind of Building-Artificers' Work; with Forms of Building Conditions and Agreements, an Appendix, Foot-Notes, and a copious Index. Edited by WILLIAM YOUNG, Architect. Crown 8vo. price 6*s.*

The LAW RELATING to BENEFIT BUILDING SOCIETIES; with Practical Observations on the Act and all the Cases decided thereon; also a Form of Rules and Forms of Mortgages. By W. TIDD PRATT, Barrister. Second Edition. Fcp. 3*s.* 6*d.*

COLLIERIES and COLLIERS: a Handbook of the Law and Leading Cases relating thereto. By J. C. FOWLER, of the Inner Temple, Barrister, Stipendiary Magistrate for the District of Merthyr Tydfil and Aberdare. Second Edition. Fcp. 8vo. 7*s.* 6*d.*

The MATERNAL MANAGEMENT of CHILDREN in HEALTH and Disease. By THOMAS BULL, M.D. Fcp. 5*s.*

HINTS to MOTHERS on the MANAGEMENT of their HEALTH during the Period of Pregnancy and in the Lying-in Room. By the late THOMAS BULL, M.D. Fcp. 5*s.*

NOTES on HOSPITALS. By FLORENCE NIGHTINGALE. Third Edition, enlarged; with 13 Plans. Post 4to. 18*s.*

The PHILOSOPHY of HEALTH; or, an Exposition of the Physiological and Sanitary Conditions conducive to Human Longevity and Happiness. By SOUTHWOOD SMITH, M.D. Eleventh Edition, revised and enlarged; with 113 Woodcuts. 8vo. 7*s.* 6*d.*

WHIST, WHAT TO LEAD. By CAM. Fourth Edition. 32mo. 1*s.*

CHESS OPENINGS. By F. W. LONGMAN, Balliol College, Oxford. Fcp. 8vo. 2*s.* 6*d.*

A PRACTICAL TREATISE on BREWING; with Formulæ for Public Brewers, and Instructions for Private Families. By W. BLACK. 8vo. 10*s.* 6*d.*

MODERN COOKERY for PRIVATE FAMILIES, reduced to a System of Easy Practice in a Series of carefully-tested Receipts. By ELIZA ACTON. Newly revised and enlarged Edition; with 8 Plates of Figures and 150 Woodcuts. Fcp. 6*s.*

ON FOOD: its Varieties, Chemical Composition, Nutritive Value, Comparative Digestibility, Physiological Functions and Uses, Preparation, Culinary Treatment, Preservation, Adulteration, &c. By H. LETHEBY, M.B. M.A. Ph.D. &c. Crown 8vo. price 6*s.*

COULTHART'S DECIMAL INTEREST TABLES at 24 Different Rates not exceeding 5 per Cent. Calculated for the use of Bankers. To which are added Commission Tables at One-Eighth and One-Fourth per Cent. 8vo. price 15*s.*

MAUNDER'S TREASURY of KNOWLEDGE and LIBRARY of Reference: comprising an English Dictionary and Grammar, Universal Gazetteer, Classical Dictionary, Chronology, Law Dictionary, a Synopsis of the Peerage, useful Tables, &c. Revised Edition. Fcp. 8vo. price 6*s.*

INDEX.

ACTON'S Modern Cookery 28
ALCOCK'S Residence in Japan 23
ALLIES on Formation of Christendom 20
Alpine Guide (The) 23
ALTHAUS on Medical Electricity 14
ANDREWS'S Life of Oliver Cromwell 5
ARNOLD'S Manual of English Literature .. 7
ARNOTT'S Elements of Physics 11
Arundines Cami 26
Autumn Holidays of a Country Parson 9
AYRE'S Treasury of Bible Knowledge..... 20

BACON'S Essays, by WHATELY 6
——— Life and Letters, by SPEDDING .. 5
——— Works, edited by SPEDDING 6
BAIN'S Logic, Deductive and Inductive 10
——— Mental and Moral Science 10
———on the Emotions and Will 10
———on the Senses and Intellect..... 10
———on the Study of Character 10
BALL'S Alpine Guide 23
BAYLDON'S Rents and Tillages 19
Beaten Tracks 23
BECKER'S Charicles *and* Gallus 25
BENFEY'S Sanskrit Dictionary 8
BERNARD on British Neutrality..... 1
BLACK'S Treatise on Brewing 28
BLACKLEY'S Word-Gossip 7
———German-English Dictionary .. 8
BLAINE'S Rural Sports 26
——— Veterinary Art 27
BOURNE on Screw Propeller 18
BOURNE'S Catechism of the Steam Engine. 18
———Handbook of Steam Engine 18
———Improvements in the Steam Engine 18
———Treatise on the Steam Engine .. 18
———Examples of Modern Engines .. 18
BOWDLER'S Family SHAKSPEARE 26
BRANDE'S Dictionary of Science, Literature, and Art..... 13
BRAY'S (C.) Education of the Feelings 10
——— Philosophy of Necessity..... 10
——— on Force..... 10
BROWNE'S Exposition of the 39 Articles.... 19
BUCKLE'S History of Civilization 4
BULL'S Hints to Mothers 28
——— Maternal Management of Children 28
BUNSEN'S (Baron) Ancient Egypt..... 4
——— God in History 3
——— Memoirs..... 5
BUNSEN (E. DE) on Apocrypha 21
———'s Keys of St. Peter..... 21
BURKE'S Vicissitudes of Families..... 5
BURTON'S Christian Church..... 4
———Vikram and the Vampire 24
Cabinet Lawyer 28

CALVERT'S Wife's Manual..... 21
CATES'S Biographical Dictionary 5
CATS' and FARLIE'S Moral Emblems 16
Changed Aspects of Unchanged Truths 9
CHESNEY'S Euphrates Expedition..... 22
——— Indian Polity 3
——— Waterloo Campaign..... 2
——— and RENVE'S Military Resources of Prussia and France, &c..... 2
CHILD'S Physiological Essays 15
Chorale Book for England..... 16
CLOUGH'S Lives from Plutarch 2
COBBE'S Norman Kings of England..... 2
COLENSO (Bishop) on Pentateuch and Book of Joshua 20
Commonplace Philosopher in Town and Country 9
CONINGTON'S Chemical Analysis 14
——— Translation of VIRGIL'S *Æneid*..... 26
CONTANSEAU'S French-English Dictionaries 8
CONYBEARE and HOWSON'S Work on St. Paul 19
COOK on the Acts 19
COOK'S Voyages 5
COOPER'S Surgical Dictionary..... 14
COPLAND'S Dictionary of Practical Medicine 15
COTTON'S Introduction to Confirmation.... 19
COULTHART'S Decimal Interest Tables 26
Counsel and Comfort from a City Pulpit.... 9
COX'S Aryan Mythology..... 4
——— Manual of Mythology 5
——— Tale of the Great Persian War..... 3
——— Tales of Ancient Greece..... 25
CRESY'S Encyclopædia of Civil Engineering 18
Critical Essays of a Country Parson 9
CROWE'S History of France 2
CULLEY'S Handbook of Telegraphy..... 17
CUSACK'S History of Ireland..... 3

D'AUBIGNE'S History of the Reformation in the time of CALVIN 2
DAVIDSON'S Introduction to New Testament 23
Dead Shot (The), by MARKSMAN 20
DE LA RIVE'S Treatise on Electricity 12
DENISON'S Vice-Regal Life 1
DE TOCQUEVILLE'S Democracy in America 2
DISRAELI'S Lothair 24
DORELL'S Reports on the Progress of Medicine 15
DOBSON on the Ox..... 27
DOVE on Storms 11
DOYLE'S Fairyland 16
DYER'S City of Rome 3

EASTLAKE'S Hints on Household Taste.... 17
———History of Oil Painting..... 16

EASTLAKE'S Gothic Revival 17
——— Life of Gibson 16
EDMUNDS'S Names of Places 9
EDWARDS'S Shipmaster's Guide 27
Elements of Botany 13
ELLICOTT on the Revision of the English New Testament 19
——— 's Commentary on Ephesians 19
——— Commentary on Galatians 19
——— Pastoral Epist. 19
——— Philippians, &c. 19
——— Thessalonians 19
——— Lectures on the Life of Christ.. 19
Essays and Contributions of A. K. H. B..... 8
EWALD'S History of Israel 20

FAIRBAIRN on Iron Shipbuilding 18
——— 's Applications of Iron 18
——— Information for Engineers .. 18
——— Mills and Millwork 18
FARADAY'S Life and Letters 4
FARRAR'S Families of Speech 9
——— Chapters on Language 7
FELKIN on Hosiery and Lace Manufactures 18
FENNELL'S Book of the Roach 26
FFOULKES'S Christendom's Divisions 21
FITZWYGRAM on Horses and Stables 27
Five Years in a Protestant Sisterhood 20
FORBES'S Earls of Granard 5
FOWLER'S Collieries and Colliers 28
FRANCIS'S Fishing Book 26
FRESHFIELD'S Travels in the Caucasus.... 22
FROUDE'S History of England 1
——— Short Studies on Great Subjects 9

GANOT'S Elementary Physics 11
GILBERT'S Cadore, or Titian's Country 22
GILBERT and CHURCHILL'S Dolomites 23
GIRDLESTONE'S High Alps without Guides 24
GOLDSMITH'S Poems, Illustrated 25
GOULD'S Silver Store 26
GRAHAM'S Book about Words 7
GRANT'S Home Politics 3
——— Ethics of Aristotle 6
Graver Thoughts of a Country Parson..... 9
GRAY'S Anatomy 15
GREENHOW on Bronchitis 14
GROVE on Correlation of Physical Forces .. 12
GURNEY'S Chapters of French History 2
GWILT'S Encyclopædia of Architecture 17

HARE on Election of Representatives 7
HARTWIG'S Harmonies of Nature 13
——— Polar World 13
——— Sea and its Living Wonders .. 13
——— Tropical World 13
HAUGHTON'S Manual of Geology 12
HAWKER'S Instructions to Young Sportsmen 26
HERSCHEL'S Outlines of Astronomy..... 11
HEWITT on Diseases of Women 14
HODGSON'S Theory of Practice 10
——— Time and Space 10
HOLMES'S System of Surgery 14
——— Surgical Diseases of Infancy.... 14
HOOKER and WALKER-ARNOTT'S British Flora 13
HORNE'S Introduction to the Scriptures.... 20
——— Compendium of ditto 20
How we Spent the Summer 22
HOWARD'S Gymnastic Exercises 15
HOWITT'S Australian Discovery..... 23
——— Northern Heights of London.... 24
——— Rural Life of England..... 24
——— Visits to Remarkable Places.... 24
HÜBNER'S Memoir of Sixtus V..... 2
HUGHES'S (W.) Manual of Geography 11

HUME'S Essays 10
——— Treatise on Human Nature 10
HUMPHREY'S Sentiments of Shakspeare.... 16

IHNE'S Roman History 3
INGELOW'S Poems 25
——— Story of Doom 26
——— Mopsa 26

JAMESON'S Saints and Martyrs 17
——— Legends of the Madonna..... 17
——— Monastic Orders 17
JAMESON and EASTLAKE'S History of Our Lord 17
JOHNSTON'S Geographical Dictionary..... 11
JUKES on Second Death 21
——— on Types of Genesis 21

KALISCH'S Commentary on the Bible 7
——— Hebrew Grammar 8
KEITH on Fulfilment of Prophecy 20
——— Destiny of the World 20
KERL'S Metallurgy by CROOKES and RÖHRIG 16
KESTEVEN'S Domestic Medicine..... 15
KIRBY and SPENCE'S Entomology..... 13

LANDON'S (L. E. L.) Poetical Works 26
LATHAM'S English Dictionary..... 7
——— River Plate 11
LAWLOR'S Pilgrimages in the Pyrenees 24
LECKY'S History of European Morals 3
——— Rationalism 3
Leisure Hours in Town 9
LESLIE on Land Systems 1
Lessons of Middle Age 9
LETHEBY on Food 28
LEWES' History of Philosophy 4
LEWIS'S Letters 5
LIDDELL and SCOTT'S Greek-English Lexicon and Abridgment 8
Life of Man Symbolised 16
Life of Margaret M. Hallahan..... 20
LINDLEY and MOORE'S Treasury of Botany 13
LINDSAY'S Evidence for the Papacy..... 20
LONGMAN'S Edward the Third 2
——— Lectures on the History of England 2
——— Chess Openings 28
Lord's Prayer Illustrated 16
LOUDON'S Agriculture 19
——— Gardening 19
——— Plants 19
LOWNDES'S Engineer's Handbook 13
LUBBOCK on Origin of Civilisation..... 12
Lyra Eucharistica 22
——— Germanica 16, 21
——— Messianica 22
——— Mystica 22

MACAULAY'S (Lord) Essays 3
——— History of England 1
——— Lays of Ancient Rome 25
——— Miscellaneous Writings 9
——— Speeches 7
——— Complete Works 1
MACFARREN'S Lectures on Harmony 16
MACLEOD'S Elements of Political Economy 7
——— Dictionary of Political Economy 7
——— Elements of Banking 27
——— Theory and Practice of Banking 27
MCCULLOCH'S Dictionary of Commerce.... 27
——— Geographical Dictionary .. 11
MAGUIRE'S Life of Father Mathew 5

MALET'S Overthrow of the Germanic Confederation by Prussia ... 2
MANNING'S England and Christendom ... 21
MARCET on the Larynx ... 15
MARSHALL'S Physiology ... 15
MARSHMAN'S Life of Havelock ... 5
——— History of India ... 3
MARTINEAU'S Endeavours after the Christian Life ... 22
MASSEY'S History of England ... 2
MASSINGBERD'S History of the Reformation ... 4
MATHESON'S England to Delhi ... 22
MAUNDER'S Biographical Treasury ... 5
——— Geographical Treasury ... 11
——— Historical Treasury ... 4
——— Scientific and Literary Treasury ... 13
——— Treasury of Knowledge ... 28
——— Treasury of Natural History ... 13
MAURY'S Physical Geography ... 11
MAY'S Constitutional History of England ... 2
MELVILLE'S Digby Grand ... 25
——— General Bounce ... 25
——— Gladiators ... 25
——— Good for Nothing ... 25
——— Holmby House ... 25
——— Interpreter ... 25
——— Kate Coventry ... 25
——— Queen's Maries ... 25
Memoir of Bishop COTTON ... 4
MENDELSSOHN'S Letters ... 5
MERIVALE'S (H.) Historical Studies ... 2
——— (C.) Fall of the Roman Republic ... 3
——— Romans under the Empire ... 3
MERRIFIELD and EVRE'S Navigation ... 11
MILES on Horse's Foot and Horseshoeing ... 27
——— Horses' Teeth and Stables ... 27
MILL (J.) on the Mind ... 10
MILL (J. S.) on Liberty ... 6
——— on Representative Government ... 6
——— on Utilitarianism ... 6
MILL'S (J. S.) Dissertations and Discussions ... 7
——— Political Economy ... 6
——— System of Logic ... 6
——— Hamilton's Philosophy ... 7
——— Inaugural Address ... 7
——— England and Ireland ... 6
——— Subjection of Women ... 6
MILLER'S Elements of Chemistry ... 13
——— Hymn-Writers ... 21
MITCHELL'S Manual of Assaying ... 18
MONSELL'S Beatitudes ... 22
——— His Presence not his Memory ... 22
——— 'Spiritual Songs' ... 22
MOORE'S Irish Melodies ... 25
——— Lalla Rookh ... 25
——— Poetical Works ... 25
——— Power of the Soul over the Body ... 21
MORELL'S Elements of Psychology ... 10
——— Mental Philosophy ... 10
MULLER'S (MAX) Chips from a German Workshop ... 10
——— Lectures on the Science of Language ... 7
——— (K. O.) Literature of Ancient Greece ... 3
MURCHISON on Liver Complaints ... 15
MURE'S Language and Literature of Greece 3

New Testament, Illustrated Edition ... 16
NEWMAN'S History of his Religious Opinions 5
NIGHTINGALE'S Notes on Hospitals ... 28
NILSSON'S Scandinavia ... 12
No Appeal ... 24
NORTHCOTE'S Sanctuaries of the Madonna 20
NORTHCOTT'S Lathes and Turning ... 17
NORTON'S City of London ... 23

ODLING'S Animal Chemistry ... 14
——— Course of Practical Chemistry ... 14
——— Manual of Chemistry ... 13
——— Lectures on Carbon ... 14
——— Outlines of Chemistry ... 14
Our Children's Story ... 25
OWEN'S Lectures on the Invertebrate Animals ... 12
——— Comparative Anatomy and Physiology of Vertebrated Animals ... 12

PACKE'S Guide to the Pyrenees ... 23
PAGET'S Lectures on Surgical Pathology ... 14
PEREIRA'S Manual of Materia Medica ... 15
PERKIN'S Italian and Tuscan Sculptors ... 17
PEWTNER'S Comprehensive Specifier ... 26
PHILLIPS'S Guide to Geology ... 12
Pictures in Tyrol ... 23
PIESSE'S Art of Perfumery ... 18
——— Natural Magic ... 18
PRATT'S Law of Building Societies ... 28
PRENDERGAST'S Mastery of Languages ... 8
PRESCOTT'S Scripture Difficulties ... 20
PROCTOR on Plurality of Worlds ... 11
——— Saturn and its System ... 11

RAE'S Westward by Rail ... 23
Recreations of a Country Parson ... 8
REICHEL'S See of Rome ... 20
REILLY'S Map of Mont Blanc ... 23
REIMANN on Aniline Dyes ... 15
REYNOLDS' Glaphyra, and other Poems ... 26
RILEY'S Memorials of London ... 23
RIVERS' Rose Amateur's Guide ... 13
ROBBIN'S Cavalry Catechism ... 27
ROGER'S Correspondence of Greyson ... 9
——— Eclipse of Faith ... 9
——— Defence of ditto ... 9
——— Essays from the *Edinburgh Review* ... 9
——— Reason and Faith ... 9
ROGET'S English Words and Phrases ... 7
Roma Sotterranea ... 24
RONALD'S Fly-Fisher's Entomology ... 26
ROSE'S Ignatius Loyola ... 2
ROWTON'S Debater ... 7
RULE'S Karaite Jews ... 20
RUSSELL'S (Earl) Speeches and Despatches 1
——— on Government and Constitution 1

SANDAR'S Justinian's Institutes ... 6
SAMUELSON'S German Working Man ... 24
SCHEFFLER on Ocular Defects and Spectacles 15
SCOTT'S Lectures on the Fine Arts ... 16
——— Albert Durer ... 16
SEEBOHM'S Oxford Reformers of 1498 ... 2
SEWELL'S After Life ... 24
——— Amy Herbert ... 24
——— Cleve Hall ... 24
——— Earl's Daughter ... 24
——— Examination for Confirmation ... 21
——— Experience of Life ... 24
——— Gertrude ... 24
——— Glimpse of the World ... 24
——— History of the Early Church ... 24
——— Ivors ... 24
——— Journal of a Home Life ... 24
——— Katharine Ashton ... 24
——— Laneton Parsonage ... 24
——— Margaret Percival ... 24
——— Passing Thoughts on Religion ... 21
——— Preparations for Communion ... 21
——— Principles of Education ... 21
——— Readings for Confirmation ... 21
SEWELL'S Readings for Lent ... 21
——— Tales and Stories ... 24
——— Thoughts for the Age ... 21
——— Ursula ... 24

SEWELL'S Thoughts for the Holy Week.... 21
SHAFTESBURY'S Characteristics..... 10
SHAKESPEARE'S Midsummer Night's Dream illustrated with Silhouettes..... 16
SHIPLEY'S Church and the World 20
——— Invocation of Saints 22
SHORT'S Church History..... 4
SMART'S WALKER'S Pronouncing Dictionary 8
SMITH'S (A. C.) Tour in Portugal..... 22
——— (Southwood) Philosophy of Health 28
——— (J.) Paul's Voyage and Shipwreck 19
——— (SYDNEY) Miscellaneous Works.. 9
——— Wit and Wisdom 9
——— Life and Letters..... 4
SOUTHEY'S Doctor 7
——— Poetical Works 25
STANLEY'S History of British Birds 12
STEBBING'S Analysis of MILL'S Logic 6
STEPHEN'S Essays in Ecclesiastical Biography 5
STIRLING'S Secret of Hegel 10
STONEHENGE on the Dog 27
——— on the Greyhound..... 27
STRICKLAND'S Tudor Princesses..... 5
——— Queens of England 5
Strong and Free 10
Sunday Afternoons at the Parish Church of a Scottish University City (St. Andrews).. 9
SWEETMAN'S Through the Night, and Onward..... 24

TAYLOR'S History of India 3
——— (Jeremy) Works, edited by EDEN 23
THIRLWALL'S History of Greece..... 2
THOMPSON'S (Archbishop) Laws of Thought 7
——— (A. T.) Conspectus 15
——— Paraguayan War 23
Three Weddings..... 24
TODD (A.) on Parliamentary Government 1
TODD and BOWMAN'S Anatomy and Physiology of Man..... 15
TRENCH'S Realities of Irish Life 3
TROLLOPE'S Barchester Towers 24
——— Warden 24
TWISS'S Law of Nations..... 27
TYNDALL on Diamagnetism..... 12
——— Heat 11
——— Sound 12
TYNDALL'S Faraday as a Discoverer 4
——— Lectures on Light..... 12
UNCLE PETER'S Fairy Tale 24
URE'S Dictionary of Arts, Manufactures, and Mines 17

VAN DER HOEVEN'S Handbook of Zoology 13

WARBURTON'S Hunting Songs 25
WATSON'S Principles and Practice of Physic 14
WATTS'S Dictionary of Chemistry 13
WEBB'S Objects for Common Telescopes .. 11
WEBSTER and WILKINSON'S Greek Testament 20
WELD'S Notes on Burgundy..... 23
WELLINGTON'S Life, by the Rev. G. R. GLEIG 5
WEST on Children's Diseases..... 14
WHATELY'S English Synonymes 6
——— Logic 6
——— Rhetoric 6
WHATELY on a Future State 21
——— ——— Religious Worship 22
——— ——— Truth of Christianity 22
Whist, what to lead, by CAM..... 26
WHITE and RIDDLE'S Latin-English Dictionaries 8
WILCOCK'S Sea Fisherman..... 27
WILLIAMS'S Aristotle's Ethics 6
——— History of Wales 2
WILLIAMS on Climate of South of France 14
——— Consumption 15
WILLIS'S Principles of Mechanism 17
WINSLOW on Light 12
WOOD'S Bible Animals 13
——— Homes without Hands 13
WOODWARD'S Historical and Chronological Encyclopædia 4

YNO'S Manual of Zoology 13
YONGE'S English-Greek Lexicons..... 8
——— Editions of Horace..... 26
YOUATT on the Dog 27
——— on the Horse 27

ZELLER'S Socrates .....
——— Stoics, Epicureans, and Sceptics.. 6

LONDON: PRINTED BY
SPOTTISWOODE AND CO., NEW-STREET SQUARE
AND PARLIAMENT STREET